SUGARBEET RESEARCH

1975 REPORT

A Report to and for
the Sole Use of Cooperators

NOT FOR PUBLICATION

F O R E W O R D

SUGARBEET RESEARCH is an annual compilation of progress reports concerning incomplete research by Agricultural Research Service investigators and cooperators who are engaged in sugarbeet variety and production research. The report has been assembled by Dr. John S. McFarlane, Technical Advisor for sugarbeet breeding. The report has been reproduced at the expense of the Beet Sugar Development Foundation, and is for the sole use of the cooperators. Much of the data has not been sufficiently confirmed to justify general release and interpretations may be modified with additional experimentation. The report is not intended for publication and should not be used for cited reference nor quoted in publicity or advertising. Reproduction of any portion of the material contained herein will not be permitted without the specific consent of the contributor or contributors.

The report presents results of investigations strengthened by contributions received under Cooperative Agreements between Agricultural Research Service, U.S. Department of Agriculture, and the Beet Sugar Development Foundation; the California Beet Growers Association, Ltd.; the Farmers and Manufacturers Beet Sugar Association; and the Sugarbeet Research and Education Board of Minnesota and North Dakota.

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SUGARBEET RESEARCH

1975 Report

Section A

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The research was supported in part by funds provided through the Beet Sugar Development Foundation (Projects 11, 12, 24, 29, and 51) and the California Beet Growers Association.

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SUMMARY OF ACCOMPLISHMENTS, 1975

EVALUATION OF A TYPE-O LINE EQUIVALENT TO C17--Many commercial sugarbeet fields in California have bolted plants that produce viable seed. Not only does the seed production itself potentially reduce sugar yield, but the seed may produce a weed and disease problem in the subsequent crop. Several studies have also indicated that a higher sugar yield is obtained where the seedstalks are not cut back to eliminate seed production. One way to possibly eliminate the seed problem would be to grow commercial hybrids that are completely male sterile. With this in mind, the type-O segregates were isolated from C17 and compared to C17 as a potential pollinator for the production of US H10 type hybrids. The type-O line per se and its hybrids are summarized for bolting, performance, and yellows resistance in the following tables. In these tables the type-O line is coded as Y417 and its hybrids as Y417H__ (e.g., Y417H8 is its hybrid with 546H3). In general, the performance of Y417 per se may be slightly poorer than C17, but the comparison of equivalent hybrids shows that they are not different as pollinators.

A CMS equivalent of Y417, coded Y417HO, was also developed. As long as hybrids with a pollinator similar to C17 are used, this CMS equivalent should be useful as a tester to determine the combining ability of potentially new, monogerm lines. Y417HO may also be useful in recurrent selection programs as a tester to identify genotypes that specifically complement hybrids with C17 or Y417 type pollinators. R. T. Lewellen, I. O. Skoyen, and J. S. McFarlane.

RECURRENT SELECTION FOR YELLOWS RESISTANCE--Using nearly the same procedures discussed in "Sugarbeet Research, 1974 Report," Pages A2, A11-12, and A31, a self-fertile composite population segregating for Mendelian male sterility was selected for yellows resistance and yield. This composite, designated 791, was primarily derived from self-fertile lines selected for adaptation to California requirements, i.e., curly top resistant and bolting resistant, but lacked any appreciable degree of yellows resistance. The results of the first cycle of selection are presented in Test 1375. The first cycle of selection did not significantly increase or decrease yellows resistance as measured by sugar-yield loss. Selecting for high gross sugar (HGS) and high sucrose percentage (HS) increased sugar yield and sucrose percentage under both yellows inoculated and noninoculated conditions for the lines per se. A second cycle of selection within the high sucrose and high gross sugar composites is now underway. R. T. Lewellen, I. O. Skoyen, and J. S. McFarlane.

INTERACTION OF YELLOWS AND POWDERY MILDEW ON YIELD OF SUGARBEET--Duplicate experiments were conducted at Salinas (Test 2175) and Davis (Test UCD) in 1975 to determine, in varieties that varied in powdery mildew and yellows virus resistance, the losses caused by combinations of infections of powdery mildew with two viruses, BYV or BWYV. The

information would be important for (1) assessing potential damage in varieties that vary in resistance to mildew and yellows; (2) decisions on the need to incorporate powdery mildew resistance into lines adapted to California; and (3) deciding use and timing of control measures if disease combinations proved more or less damaging than that of independent infections. Gross sugar losses due to powdery mildew ranged from 1 to 15% at Salinas and from 14 to 21% at Davis in 1975. In 1974 the gross sugar loss was nearly 30% for both locations. Losses in gross sugar due to yellows for the test varieties ranged from 21 to 32% (Salinas) and 24 to 46% (Davis) for BYV, and from 2 to 19% (Salinas) and 3 to 30% (Davis) for BWYV. Disease losses, as measured by gross sugar, that resulted when plots were singly infected with powdery mildew, BYV, or BWYV were essentially additive when compared with the losses in plots infected with combinations of mildew and viruses. Test variety 3204 (from Holland) proved to be resistant to both yellows viruses and was as resistant to powdery mildew as any line that has been observed in the Salinas breeding program. This suggests that it should be possible to select for or combine mildew resistance in our mildew susceptible lines and retain yellows resistance. The resistance of 3204 probably would be adequate to prevent damage from even a moderately severe powdery mildew infection. I. O. Skoyen, R. T. Lewellen, F. J. Hills, and J. S. McFarlane.

RESISTANCE TO BEET MOSAIC VIRUS--Tests at Salinas in 1974 (Test 1874, Sugarbeet Research, 1974 Report) and 1975 (Tests 2275 and 2375) show that beet mosaic virus (BMV) collected from commercial fields causes significant sugar yield losses. These losses are about half those caused by beet yellows virus and are about equal to those caused by beet western yellows virus. The losses in performance associated with BMV infection can essentially be eliminated by the incorporation of the Bm allele. BMV resistant lines nearly equivalent to C17, C01, etc., have been developed and these are being evaluated as potential pollinators for the production of yellows and mosaic resistant hybrids. BMV resistance may be as important as yellows resistance in certain areas of the Sacramento Delta. R. T. Lewellen and I. O. Skoyen.

RESISTANCE TO ERWINIA--Selections made from C413 for Erwinia rot resistance were evaluated as lines per se and as pollinators of hybrids nearly equivalent to US H9B. As lines per se, the selections had better rot resistance than C413 and C17. This was evident in both injured and inoculated tests and in noninoculated tests. The hybrids were also generally superior to US H10B in rot resistance and nearly equal in other performance traits. These field data suggest that the Erwinia resistance of US H9 and US H10 type hybrids can be improved without the concurrent loss of other desirable characteristics, e.g., yellows resistance. Tests with segregating populations suggested that a dominant factor may condition the highly resistant reaction. R. T. Lewellen and E. D. Whitney.

POWDERY MILDEW RESISTANCE--Powdery mildew infection was light in the Salinas trials until late summer. Moderately severe infection occurred during August in an April-planted trial which included varieties and breeding lines furnished by sugarbeet breeders throughout the United States. A wide range in resistance was observed (pages A17 and A35). None of the entries proved to be immune or highly resistant. Curly top resistant varieties developed by ARS and the sugar companies tended to be among the most susceptible entries in the trials. Opportunities exist for improving the resistance of our commercial varieties but resistance may need to be introduced from curly top susceptible material. J. S. McFarlane, I. O. Skoyen, and R. T. Lewellen.

DIPLOID-TRIPLOID TESTS--Comparisons were made between corresponding diploid and triploid hybrids involving curly top resistant female parents and the yellows resistant C17 (2n) and (4n) pollen parents. In tests at both Brawley and Salinas, differences in root yields at the diploid and corresponding triploid hybrids were not significantly different (pages A26 and A42). Sucrose percentages were higher for the diploid hybrids at Brawley but no significant differences occurred at Salinas. Bolting was greater in the diploid hybrids at both Brawley and Salinas. The pollen parent C17 had 20.1% root rot caused by Erwinia species whereas the corresponding tetraploid had 41.8% (page A34). The triploid hybrids consistently showed more rot than did the diploid hybrids. Triploid hybrids involving the C17 (4n) pollinator should not be used commercially because of their high Erwinia susceptibility. J. S. McFarlane, I. O. Skoyen, and R. T. Lewellen.

BOLTING RESISTANCE OF US H9 AND US H10 SEED LOTS--Twelve seed lots of US H9 and US H10 were evaluated for bolting resistance in a November 22 planting. Included were seed increases made at Salinas and Salem, Oregon, between 1968 and 1974. Bolting was heavy and significant differences were observed among seed lots (page A38). Greatest differences were observed among seed lots produced in different years, but significant differences also occurred among seven seed increases of US H10 made at Salem in 1974. J. S. McFarlane and I. O. Skoyen.

INTERSPECIFIC HYBRIDIZATION--A segment of a Beta procumbens chromosome bearing the gene or genes for nematode resistance has been transferred to a B. vulgaris chromosome. Many diploid nematode resistant plants have been obtained, but the frequency of resistance transmission in these plants is low. The transmission rate in F_2 progenies from F_1 nematode resistant plants varied from 7% to 27%. Selections have been made from F_2 progenies with the highest transmission rates. Tests with the F_3 progenies from these selections also showed a high transmission rate. The transmission of curly top resistance to the B_6 progenies of 14 B_5 curly top resistant plants from vulgaris x corolliflora hybrids was very low (2-3%). It is possible that curly top resistance is controlled by several genes. If this is true, larger populations will need to be screened in order to identify resistant plants. Helen Savitsky and J. S. McFarlane.

INTERSPECIFIC HYBRIDIZATION STUDIES--For nematode resistance the transmission rate of the diploid nematode resistant plants under study was estimated to be 22%, and that of trisomics was 8.62% (page A55). Transmission of extra chromosome(s) through pollen was postulated by the evidence that a 20-chromosome nematode resistant plant was recovered among the progeny of nematode resistant diploid plants. Trivalents were rare; instead, univalents were more frequently observed in the meiosis of trisomic sugarbeets. Several pretreatment chemicals were tested to facilitate somatic chromosomal study. Some 40 different sources of Patellares seeds were obtained. Not every source has shown immunity from nematode infection. With these wild species, further interspecific hybridization will be made in order to introduce valuable germplasms into cultivated sugarbeets. M. H. Yu.

TOLERANCE TO WILTING CAUSED BY THE SUGARBEET NEMATODE--Another group of lines selected for nematode wilting tolerance by the Instituut voor Rationele Suikerproductie in the Netherlands was evaluated at Salinas. Two trials were grown side by side--one on land with a severe infestation of the sugarbeet nematode, and the second on land that had been fumigated in 1973. A light nematode infestation had reappeared in the fumigated area. The two trials received the same agronomic treatment. Striking differences were observed in the severity of wilting in the nematode infested area (page A39). All lines selected for wilt tolerance showed less wilting than did the US H10 check variety.

Even though the wilt tolerant selections were attacked by nematodes, yield losses were less than for the unselected check. These results are in agreement with those for other wilt tolerant selections tested in 1973 and 1974. J. S. McFarlane.

RELATIONSHIP OF AGE OF PLANTS AND RESISTANCE TO CURLY TOP VIRUS--Strains of the curly top virus capable of causing appreciable damage to resistant cultivars of sugarbeets are found throughout the western United States. Little knowledge is available regarding the extent of the damage induced by these isolates. Replicated field trials with sugarbeets have indicated that current strains of the curly top virus caused serious losses, even as late as 10 weeks after seeding or after more than 40% of the growing period had elapsed. Both yield components, root yield and sugar content were significantly reduced. Differences in incubation period rather than differences in the ability of the resistant cultivars to recover from the effects of virus infections are probably the most significant factors in disease resistance. J. E. Duffus and I. O. Skoyen.

NEMATOLOGY STUDIES--Field experiments established that aldicarb, carbofuran and phenamiphos effectively controlled Heterodera schachtii on sugarbeet at rates recommended by the suppliers. Nematode control increased yields of beets and sugar. Although dasanit controlled H. schachtii, this material was extremely toxic to sugarbeet and greatly reduced yields.

The hatch factor in sugarbeet root diffusate has been obtained in a nearly pure state and appears to be an acidic compound containing sulfur and nitrogen with a molecular weight between 3000 and 4000. Treatments of 500 µg/ml AC 64,475 permanently inhibited hatching of H. schachtii, whereas lower concentrations only temporarily inhibited hatching. Concentrations of carbofuran in excess of 50 µg/ml completely but only temporarily inhibited hatching. A. E. Steele.

ABSTRACTS OF PAPERS PUBLISHED OR APPROVED FOR PUBLICATION, 1975

DUFFUS, JAMES E. Effects of beet western yellows virus on crambe. Approved by ARS for publication in Phytopathology.

Beet western yellows virus (BWYV) causes stunting and interveinal reddening of Crambe abyssinica and is potentially very destructive. Milder isolates of the virus delayed flowering one week, reduced seed yield over 65%, and reduced seed size by 8%. A severe isolate killed over one-half of the inoculated plants, delayed flowering two weeks, reduced seed yield of the remaining plants by more than 95%, and reduced seed size by over 40%. Variation in the reaction of Crambe to BWYV may indicate resistance to the virus.

DUFFUS, JAMES E. and G. E. RUSSELL. Serological relationship between beet western yellows and beet mild yellowing viruses. Phytopathology 65: 811-815. 1975.

A possible relationship between beet western yellows virus (BWYV), the most common virus of sugarbeet in the United States, and beet mild yellowing virus (BMYV), the most prevalent virus of sugarbeet in Europe, has long been suspected. Differences between the viruses in regard to symptomology on beets, epidemiology and host range and the lack of a serological test has hampered studies on their relationships. Twelve BMYV isolates from sugarbeet in England were transferred by Myzus persicae to Capsella bursa-pastoris and studied in regard to host range, membrane feeding, and serology. The BMYV isolates produced a common reaction on certain key indicator hosts. Beta vulgaris, Capsella bursa-pastoris, and Claytonia perfoliata were all susceptible whereas Raphanus sativus, Lactuca sativa, Brassica pekinensis, and Brassica rapa were all immune. Numerous early trials with membrane feeding of BMYV failed and was thought to be another factor pointing to the differences between BMYV and BWYV. However, early in 1971, by use of highly concentrated preparations, BMYV was transmitted by M. persicae which had acquired virus by feeding on purified preparations through artificial membranes. In density-gradient columns, the positions of infectious zones of BMYV corresponded closely with those in gradients containing BWYV. Differences in transmission efficiency through membranes between common BWYV isolates and the BMYV isolates tested seems to be related to virus concentration differences in their hosts. Antisera prepared against 10 strains of BWYV from the United States and England neutralized infectivity of all isolates of BMYV tested. Antisera prepared against the English isolates of BMYV neutralized the infectivity of the American and English BWYV strains, and also the BMYV isolates. The results of these investigations establish a close serological relationship between BWYV from the United States and BMYV from Europe.

HILLS, F. J., D. H. HALL, I. O. SKOYEN, and L. D. LEACH. Powdery mildew-A new disease in California sugarbeet fields. The California Sugar Beet-1974. p. 54-55. 1975.

Powdery mildew, a common sugarbeet disease in Europe, occurred in epidemic proportions in California in 1974. Tests at Davis and Salinas showed that the disease caused a loss in both beet yield and sucrose percentage. Control of the disease increased sugar yield by about 38%. Sulfur application provided satisfactory control.

HOEFERT, LYNN L. Tubules in dilated cisternae of endoplasmic reticulum of Thlaspi arvense (Cruciferae). Amer. J. Bot. 62: 756-760. 1975.

Tubular inclusions in dilated cisternae of endoplasmic reticulum (ER) were found in healthy and virus diseased pennycress (Thlaspi arvense L., Cruciferae). The dilated cisternae were encountered more often in virus-infected cells than in comparable cells from healthy control plants. Dilated ER cisternae were found in vascular parenchyma cells and were shown to be interconnected. The tubules measured 30 nm in diam and cisternae that contain them may be more than 10 μm in length.

LEWELLEN, R. T. and E. D. WHITNEY. Inheritance of resistance to race C2 of Cercospora beticola in sugarbeet. Approved by ARS for publication in Crop Sci.

Crosses between sugarbeet (Beta vulgaris L.) lines that differed in their reaction to race C2 of Cercospora beticola Sacc. were studied in F_1, F_2, testcross, and F_2 resistant x susceptible populations. Resistance to race C2 was shown to be conditioned by a single dominant gene (Cb = resistant, cbcb = susceptible). The Cb allele had no influence on reaction to race C1. Sugarbeet lines with quantitatively inherited resistance to Cercospora leaf spot but without the Cb allele displayed nearly equal reactions to isolates of both races. The resistant reaction in sugarbeet was manifested either by apparent immunity or by a highly resistant fleck reaction. Of the lines surveyed, the Cb allele was found only in lines derived from 'GW 359.'

MACDONALD, J. D., L. D. LEACH, and J. S. MCFARLANE. Susceptibility of sugarbeet lines to the stalk blight pathogen Fusarium oxysporum f. sp. betae. Approved by ARS for publication in Plant Dis. Reptr.

Seed crops of sugarbeet (Beta vulgaris L.) hybrids US H9 and US H10 are severely affected by Fusarium oxysporum of sp. betae in the Willamette Valley of Oregon. Field trials conducted during 1973 and 1974 showed that susceptibility is carried in the male-sterile components of these hybrids and that the pollinator lines are relatively resistant. Evaluation of the hybrids, which are grown extensively throughout California, indicates that they are less susceptible than their male-sterile components.

MCFARLANE, J. S. Factors affecting sugarbeet seed germination in North America. I.I.R.B. 7: 1-9. 1975.

Sugarbeet seed is produced by the overwintering method in the United States and Canada. Over 95% of the seed is monogerm. Low seed germination is often a critical problem and is a deterrent to the complete success of precision sowing. Underdeveloped seeds are a contributing factor to low germination and may occur at all locations on a seed plant. The causes for these underdeveloped seeds are not fully understood. Immature fruits tend to occur on the tertiary branches of the plants and at the tips of the branches but usually account for only a small portion of the underdeveloped seeds. The feeding of lygus bugs on soft developing fruits causes the collapse of embryos; however, these insects can be effectively controlled with insecticides and usually cause minor damage. Parthenocarpy is known to occur and could be a partial explanation for the occurrence of empty fruits. Nutritional deficiencies or excesses tend to have an adverse effect on germination, but the problem of underdeveloped seed apparently is not closely associated with soil fertility.

The presence of chemical inhibitors in the fruits of sugarbeets can cause low germination in seed testing laboratories. At least ten organic compounds in addition to ammonia have been shown to inhibit germination. These substances can be removed by soaking the seed in water prior to the germination test. The pericarp, or maternal tissue surrounding the seed, may also cause a physical impairment to germination. There is evidence that the seed caps produced on monogerm seed may under some circumstances be thicker and tighter than on multigerm seed produced in the same area.

The wide differences that have been observed in germination of different lots of the same variety produced in any given year indicate that environment is more important than heredity with our present commercial varieties. Speed of germination and ability to germinate at low temperature are known to be heritable.

MCFARLANE, J. S. Naturally occurring hybrids between sugarbeet and Beta macrocarpa in the Imperial Valley of California. J. Amer. Soc. Sugar Beet Technol. 18: 245-251. 1975.

Wild beets identified as B. macrocarpa are widespread in the Imperial Valley of California. Seeds of this species are thought to have been introduced from the Mediterranean area prior to 1928. B. macrocarpa crosses readily with the cultivated sugarbeet, but crossing is normally prevented by a wide difference in flowering dates for the two species. Hybridization apparently occurred a few years ago in an area west of Imperial, California. Intercrossing has taken place, and wild-beet hybrids that vary greatly in plant and root characteristics occur in a 10-to-12-square mile area. These wild beets and wild-beet hybrids create a serious weed problem, especially in sugarbeet fields. Control can be obtained through removal of B. macrocarpa from noncrop areas and by prevention of hybridization with sugarbeet. When fields become badly infested with wild-beet hybrid seed, sugarbeets should not be grown until the infestation is brought under control.

SAVITSKY, HELEN. Hybridization between Beta vulgaris and B. procumbens and transmission of nematode (Heterodera schachtii) resistance to sugarbeet. Can. J. Genet. Cytol. 17: 197-209. 1975.

Triploid hybrids between tetraploid Beta vulgaris (4x = 36) and diploid B. procumbens (2x = 18) were used to transmit nematode resistance into sugarbeet. In meiosis of triploid hybrids, nine B. vulgaris bivalents and nine B. procumbens univalents were usually observed. In some pollen mother cells (PMC's) trivalent associations ($8_{II} + 8_{I} + 1_{III}$) were formed. The second anaphase varied from near regular to very irregular. The regular anaphase produced normal tetrads and viable gametes.

The B_1 plants and the plants of all succeeding backcross generations were tested for nematode resistance. From 6,750 B_1 plants, four nematode-resistant trisomics were selected that had 18 B. vulgaris chromosomes and one B. procumbens chromosome responsible for resistance. The B. procumbens chromosome and nematode resistance were transferred to the eighth backcross generation with an average transmission rate of 12%. In meiosis of trisomics, trivalent associations of two B. vulgaris and one B. procumbens chromosomes were formed in a few PMC's. Two diploid nematode-resistant plants were selected from 8,834 backcross plants in the progenies of trisomics, and resistance was transferred from both of these plants to F_1 hybrids. The segment of the B. procumbens chromosome bearing the gene for nematode resistance has been transferred to a sugarbeet chromosome.

SKOYEN, I. O., R. T. LEWELLEN, and J. S. MCFARLANE. Effect of powdery mildew on sugarbeet production in the Salinas Valley of California. Plant Dis. Reptr. 59: 506-510. 1975.

Powdery mildew, Erysiphe polygoni type, a common sugarbeet disease in Europe and the Middle East, was epiphytotic in California in 1974. The disease, first observed in the Imperial Valley of California in early April, spread to sugarbeet production areas throughout the State in about 3 months. Tests at Salinas showed that spray applications of wettable sulfur effectively suppressed the disease and increased root yield, sucrose percentage, and purity. Control of the disease with sulfur increased sugar yield by about 38%. Powdery mildew severity varied on cultivars and breeding lines from divergent sources.

STEELE, A. E. Effects of oxime carbamate nematicides on development of Heterodera schachtii on sugarbeet. Accepted for publication in J. Nematol. Vol. 8. 1976.

Treatment of sugarbeet, Beta vulgaris L., with aldicarb, aldicarb sulfoxide or aldicarb sulfone 10 days after plants were inoculated with Heterodera schachtii prevented development of the nematode, but second-stage larvae penetrated the roots. These chemicals had no measurable

effects on nematodes in plants treated 15 days after inoculation. The tests established that soil treatments of aldicarb are directly or indirectly lethal to larvae developing within roots of sugarbeet. Heterodera schachtii failed to develop on root slices of red table beet grown in soil treated with aldicarb or aldicarb sulfoxide. Similar treatment of plants with aldicarb sulfone or oxamyl did not affect subsequent development of H. schachtii on root slices of treated plants.

STEELE, A. E. Improved methods of hatching Heterodera larvae in screening tests of chemicals. Accepted for publication in J. Nematol. Vol. 8. 1976.

The rate of hatching Heterodera schachtii larvae was greatly increased by placing cysts in sieves enclosed by small disposable cups. An apparatus that permitted rapid storage of second stage larvae at 10 C prolonged the viability of the larvae.

WHITNEY, E. D. and R. T. LEWELLEN. Comparison and distribution of races C1 and C2 of Cercospora beticola from sugarbeet. Approved by ARS for publication in Phytopathology.

Based on differential host reactions, 14 sugarbeet isolates of Cercospora beticola from California, Colorado, Maryland, and Texas were classified as either physiological race C1 or C2. Race C2 occurred in California and Maryland, and race C1 was found from all four states. The races could not be distinguished by morphological or cultural characteristics; however, there were large differences between isolates. The interaction of isolate and growth media (sugarbeet leaf extract agar, water agar, and sugarbeet) was highly significant as measured by spore and condiophore length. In general, race C2 isolates were more aggressive on the susceptible cultivar than were race C1 isolates.

Published Papers Abstracted in Sugarbeet Research, 1974 Report

STEELE, A. E. Population dynamics of Heterodera schachtii on tomato and sugarbeet. J. Nematol. 7: 105-111. 1975.

STEELE, A. E. and L. R. HODGES. In-vitro and in-vivo effects of aldicarb on survival and development of Heterodera schachtii. J. Nematol. 7: 305-312. 1975.

BOLTING AND VARIETY TRIALS, SALINAS, CALIFORNIA, 1974-75

Location: USDA Agricultural Research Station

Soil type: Sandy loam (Chualar series)

Previous crops: Fallow, 1974; barley, 1973; fallow, 1972; sugarbeet trials, 1971.

Fertilizer used: Tests 175 through 975 (bolting evaluation trials) were seeded between November 20 and 23, 1974. Preplant: 280 lbs/A 5:20:10 was broadcast and chiseled in before listing; 82 lbs/A actual N, as ammonium sulfate. Sidedressing: 88 lbs/A actual N on April 11; 84 lbs/A actual N on July 9, 1975, all applications as ammonium sulfate.

Tests 1075 through 1575 (variety yield trials) were seeded between December 18 and 20, 1974. Preplant: 280 lbs/A 5:20:10 broadcast and chiseled in before listing; 89 lbs/A actual N, as ammonium sulfate. Sidedressing: 72 lbs/A actual N, April 15-21; 87 lbs/A actual N on July 9-10, 1975, all applications as ammonium sulfate.

Test 1675 (powdery mildew resistance evaluation) and powdery mildew resistance selection block area received 820 lbs/A agricultural dolomite lime (equivalent to 105% $CaCO_3$) broadcast and disced in to about 6" depth. Preplant: 280 lbs/A 5:20:10 was broadcast and chiseled in before listing; 80 lbs/A actual N, as ammonium sulfate. Sidedressing: 91 lbs/A actual N, May 21 and 84 lbs/A actual N, July 14, all applications as ammonium sulfate. Seeded: February 27.

Tests 1775, 1875 and 1975 (powdery mildew resistance observation trials) were seeded April 1. Preplant: 275 lbs/A 5:20:10 was broadcast and chiseled in before listing; 89 lbs/A actual N. Sidedressing: 75 lbs/A actual N, June 16 and 84 lbs/A actual N, July 16. All applications of N as ammonium sulfate.

Tests 2075 through 2375 (progeny and disease evaluation tests) seeded May 7 to 9. Test area received 820 lbs/A agricultural dolomite lime (eq. 105% $CaCO_3$) broadcast and disced in to about 6" depth. Preplant: 280 lbs/A 5:20:10 was broadcast and chiseled in before listing; 80 lbs/A actual N. Sidedress: 84 lbs/A actual N July 21. All applications of N as ammonium sulfate.

Tests 2475, 2575 and selection blocks (Erwinia resistant selection, inheritance of Erwinia resistance, and yellows resistance selection blocks) were seeded June 5 and 6. Test area received 820 lbs/A agricultural dolomite lime (eq. 105% $CaCO_3$) broadcast and disced in to about 6" depth. Preplant: 280 lbs/A 5:20:10 was broadcast and chiseled in before listing; 80 lbs/A actual N. Sidedress: 84 lbs/A actual N July 21. All applications of N as ammonium sulfate.

Thinning dates (1975): Tests 175 through 975: January 28-30.
Tests 1075 through 1575: February 21-26.
Test 1675: March 28.
Tests 1775 through 1975: May 6-9.
Tests 2075 through 2375: June 10-12.
Tests 2475 and 2575: July 8-10.

Inoculation dates (1975): Tests 1275 through 1575: May 22 with a combination of BYV-BWYV.
Test 2075: June 26 with a combination of BYV-BWYV.
Test 2175: July 8 with BWYV and July 9 with BYV.
Test 2275: June 27 with BMV; July 9 with BYV and a combination of BYV-BWYV.
Test 2375: June 27 with BMV; July 9, with a combination of BYV-BWYV.
Tests 2475 and 2575 and Erwinia resistance selection block: July 30 and 31 with a suspension of Erwinia root rot bacterium.

Harvest dates (1975): Tests 175 through 775 not harvested for yield.
Tests 875 and 975: September 9-16.
Test 1075: September 17 and 18.
Test 1175: September 29-30 and October 1.
Test 1275: October 6-8.
Test 1375-1: October 1-2.
1375-2: September 24-25.
Test 1475: September 22-24.
Test 1575: September 18-19.
Test 1675: October 9-10.
Test 2075: October 28-29.
Test 2175: October 23-24.
Test 2275: Replications 1-5, October 20-21 and replications 6-10, October 14-16.
Test 2375: October 16-17.
Test 2475: October 6.
Test 2575: October 6-9.

Irrigation: By either furrow or sprinkler system as required at 7-14 day intervals starting May 12. Timely rainfall occurred during early 1975 so that only light stand establishment sprinkler irrigations were required prior to mid-May.

Diseases and insects: Virus yellows infection was moderate during 1975. Scattered infection centers of yellows were evident by early May and aphid populations were increasing at that time; however, a sidedressing of Temik 10G controlled the aphid and slowed the spread of yellows. Twenty-five lbs/A of Temik 10G was applied to

Tests 175 through 1675 between May 5 and 13 and to tests 1775 through 1975 on May 27. Later seeded tests 2075 through 2575 were sidedressed with 25 lbs/A Temik 10G on July 21 and 22. By September 1 the spread of yellows had become general and by harvest control and yellows inoculated plots were essentially indistinguishable.

Powdery mildew infection developed in the same manner as in 1974 with the first infection occurring in the earliest seeded tests. Mildew was controlled with a single application of wettable sulfur (10 lbs/A in 120 gal H_2O at 300 PSI) for tests 275 through 1575. The sulfur was applied between June 11 and 20. Mildew was controlled with sulfur as needed in later seeded tests.

Experimental design: Test 175: 96 entries, in one-row plots with 2 replications, plot rows 32' long.
Tests 275 and 375: 12 entries in one-row plots with 4 and 5 replications, respectively, plot rows 53' long.
Test 475: 24 entries in one-row plots with 2 replications, plot rows 25' long.
Test 575: 88 entries in one-row plots with 2 replications, plot rows 32' long.
Test 675: 64 entries in one-row plots with 4 replications, plot rows 32' long.
Test 775: 12 entries in one-row plots with 4 replications, plot rows 32' long.
Test 875: 64 entries in one-row plots with 4 replications, plot rows 32' long.
Test 975: 28 entries in one-row plots with 5 replications, plot rows 53' long.
Test 1075: 9 entries in two-row plots with 10 replications, plot rows 53' long.
Test 1175: 18 entries in two-row plots with 10 replications, plot rows 53' long.
Test 1275: 24 entries (in split plots) in one-row plots with 7 replications, plot rows 37' long.
Test 1375-1 and 1375-2: 21 entries in one-row plots with 7 replications, plot rows 37' long.
Test 1475: 26 entries (in split plots) in one-row plots with 7 replications, plot rows 37' long.
Test 1575: 10 entries (in split plots) in one-row plots with 7 replications, plot rows 37' long.
Test 1675: 12 entries (in split plots) in two-row plots with 5 replications, plot rows 53' long.
Test 1775: 32 entries in two-row plots with 4 replications, plot rows 32' long.
Test 1875: 48 entries in two-row plots with 2 replications, plot rows 32' long.

Test 1975: 16 entries in two-row plots with 2 replications, plot rows 32' long.
Test 2075: 72 entries split into six subtests of 24 entries each in one-row plots with 4 replications, plot rows 20' long.
Test 2175: 4 entries, 3 viruses and 2 powdery mildew treatments in split-split plots with one-row plots and 5 replications, plot rows 53' long.
Test 2275: 24 entries with 4 virus treatments in split blocks, and one-row plots with 10 replications, block rows 109' long split into block rows 25' long.
Test 2375: 8 entries with 4 virus treatments in split blocks, and one-row plots with 5 replications, block rows 109' long were split into 25' long sub-block rows.
Test 2475: 12 entries in one-row plots with 8 replications, plot rows 32' long.
Test 2575: 6 entries in one-row plots with 10 replications, plot rows 53' long.

Sugar analysis: Determined from one or two samples per plot of approximately 10 roots each at the sugar analytical laboratory, U.S. Agricultural Research Station, Salinas, California.

Remarks: The assistance of Dr. F. J. Hills and Ms. Patricia Thomas, University of California at Davis, in the analysis of test data is gratefully acknowledged.

Bolting Resistance Evaluation Test, Salinas, California, 1974-75
Test 175

2 replications
1 row plots, 32 ft. long

Planted: November 20, 1974

Variety	Description	Bolting 7/17 %	Bolting 8/25 %	Powdery Mildew 6/30 Grade[1/]
417Tmm	Tetra of 417mm	0.0	1.1	1.5
4547H1	502H0 x 547	3.2	5.2	3.0
417T	Tetra of C17	2.2	6.7	1.5
3536-97H54	705H0 x 536-97	6.9	7.9	3.0
444T	(330 x 234) tetra	4.0	11.8	1.5
434T	Tetra of Netherlands 234	6.9	12.5	1.0
417TH28	536-97H3 x C17 (4n)	5.9	12.8	2.5
585	Type O S st	6.1	14.5	1.5
417H21	536-97H0 x C17	8.7	14.6	2.5
417H28	536-97H3 x C17	6.8	15.8	2.0
417H29	(718H0 x 536-97) x C17	11.8	16.7	1.5
464H2	US H6	5.8	17.2	2.0
3536-97H72	718H0 x 536-97	10.9	17.4	3.0
417TH21	536-97H0 x C17 (4n)	11.1	17.5	2.0
417TH29	(718H0 x 536-97) x C17 (4n)	3.1	18.2	1.5
417H25	1565H52 x C17	8.6	19.4	2.0
434	Inc. (aamm S st x 813)	15.1	19.8	2.0
417H27	(718H0 x 565) x C17	13.5	19.9	2.0
Maris Vanguard		8.9	20.8	2.0
417H8	US H10B	5.7	21.6	2.0
4554H4	3565H0 x 2554 (Iso.)	9.7	22.5	1.5
417H26	(536H1 x 565) x C17	12.8	23.3	2.5
534	Inc. yel. res. line from Netherlands	11.7	23.3	2.0
3536-97H3	562H0 x 536-97	10.5	23.8	3.0
Y004	413 x 234	18.2	24.3	2.0
Y003	Yellows res. line	9.9	24.6	1.5
Vytomo	Swedish var.	8.9	25.6	1.5
Y401H29	(718H0 x 536-97) x Y401	12.8	26.9	2.5
435	Inc. (aamm S st x 813)	13.9	27.8	2.5
417TH8	US H10B (3n)	19.7	29.9	1.5
464	Pollinator line	26.1	30.0	0.5
3546H72B	718H0 x 546	17.6	30.5	2.5
F70-13(C413)	Inc. F66-13	32.0	34.4	2.0
3565H54	705H0 x 565	26.0	34.8	2.0
915	US 15	28.2	35.0	0.5
959	US 56	28.8	39.3	2.0
3522-25H85	536H61 x 522-25	18.3	41.0	2.5
3718H3 Sp.	562H0 x 718	23.3	43.3	2.5
921	Composite of Type O's	34.0	47.7	1.0

Bolting Resistance Evaluation Test, Salinas, California, 1974-75 cont.
Test 175

2 replications
1 row plots, 32 ft. long

Planted: November 20, 1974

Variety	Description	Bolting 7/17 %	Bolting 8/25 %	Powdery Mildew 6/30 Grade[1/]
F66-546H3	562HO x 546	27.6	48.0	2.0
Dep 2	Line from Deprez	27.5	50.0	1.5
2522-29H23	522-25HO x 522-29	29.5	50.5	2.5
3565H54	705HO x 565	26.0	34.8	2.0
F63-569H3	562HO x 569	48.1	62.2	2.5
Dep 1	Line from Deprez	45.9	66.4	1.0
Y001	Yellows res. composite	49.4	68.9	2.0
4539H4	US H8	45.0	69.7	2.5
ACS 1	S-72-320	72.0	75.4	1.0
4918	Inc. 203/71 (Poland)	62.7	77.7	1.5
4919	Inc. 370/17 Type O (Poland)	88.2	93.7	1.5
R655	Yaltushkovsk mm	89.9	98.0	1.0
R653	Uladovsk 20 mm	87.4	98.1	1.0
R641	Pervomaisk polyhybrid 10	99.0	100.0	1.0
Inbred				
2512	NB 6	0.0	0.0	1.0
2547	NB 5	1.2	1.2	2.0
4569	mm inbred	1.6	1.6	2.0
7716	Yel. res. inbred	3.2	3.2	1.5
4536-97	CTR inbred	0.0	3.6	3.0
4436	Inc. S_1(5401 x 5509T)	3.3	5.5	2.0
4438	Inc. S_1(6757Trr x 6704TR)	3.2	9.5	2.0
4536-97R	CTR inbred	6.0	10.0	2.0
3536-97	Inc. 8536-97C2rr	6.8	13.5	2.5
4554	NB 4	8.9	18.5	1.0
4536-97HO	CMS of 4536-97	19.5	19.5	3.0
3718HO Iso.	2718HO x 1718	8.3	21.2	2.0
4524	Inc. S_1(Type O 704 x 9522-25)	6.8	21.8	2.0
4523	Inc. S_1(Type O 713A x 9522-25)	20.7	23.0	2.0
4502	S_{21} NB 1	7.8	24.4	2.0
3718 Iso.	Inc. 1718	6.7	25.6	2.0
1502	NB 1	6.6	25.7	2.0
3522-25	CTR inbred	16.8	28.5	2.0
3718 Sp.	Yel. res. inbred	16.9	33.8	2.0
3522-25HO	1522-25HO x 1522-25	18.6	34.7	2.0
3536-97HO	1536HO x 8536-97C2rr	21.2	37.2	3.0
3718HOB Sp.	2718HO x 1718, 2718	17.0	39.3	2.0

Bolting Resistance Evaluation Test, Salinas, California, 1974-75 cont.
Test 175

2 replications
1 row plots, 32 ft. long Planted: November 20, 1974

Inbred	Description	Bolting 7/17 %	Bolting 8/25 %	Powdery Mildew 6/30 Grade 1/
4522-29	CTR inbred	25.7	42.8	2.0
2502H0	1502H0A x 0502	22.7	43.8	2.0
4564aa	Mendelian 564	25.2	45.3	2.0
F63-546	NB inbred	41.7	47.0	2.0
F66-563H0	CMS of 563	47.1	53.1	2.0
3705	Inc. 2705	46.1	54.1	1.5
F64-550	NB inbred	45.8	55.0	2.0
F66-562	mm inbred	44.1	59.5	2.0
3565H0	F67-564H0 x 1565	52.8	60.9	2.0
F66-562H0	CMS of 562	47.0	63.4	2.0
3592	Inc. 4592	54.7	63.6	2.0
4539	NB 8	55.4	65.3	2.0
6632	aaDDR	56.6	67.1	2.0
3565	Inc. 1565	55.6	67.1	2.0
1565H0	F68-564H0 x C9564	66.0	72.0	2.0
F66-569	NB inbred	59.9	86.1	2.0
F63-539	NB 8	81.7	87.2	2.5
1502H0	0502H0 x 0502	84.6	96.9	2.0
3511	NB 2	86.7	97.9	1.0
Mean		28.2	38.3	--
LSD (.05)		12.5	15.8	--
Coefficient of Variation (%)		22.3	20.8	--
F value		33.75**	22.83**	--

**Exceeds the 1% point of significance (F = 1.59).

1/ 0 = No mildew 9 = Severe mildew

TEST 475. BOLTING EVALUATION TEST, SALINAS, CALIFORNIA, 1975

2 replications
1-row plots, 32 ft. long

Planted: November 20, 1974

Variety	Description	7/9 Bolting Percent	8/25 Bolting Percent
Y402	Inc. 2216	13.5	27.7
Y421	Inc. 2217	52.3	67.0
Y416	YRS Y116	60.8	86.6
Y424	YRS Y124	100.0	100.0
Y425	YRS Y125	100.0	100.0
4740H2B	3789H72 x 2775,6	22.3	30.1
4741H2	3790H72 x 2792,3,4,5	7.9	13.5
4755H3	F66-562H0 x 2755A	19.9	28.6
4755H72	C718H0 x 2755A	16.8	36.0
4789H2B	3789H72 x 3789	9.2	27.8
4790H2B	3790H72 x 3790	18.6	31.6
4796-1	2798aa x 3761,2	22.4	25.1
4796-2	2797aa x 3761,2	24.8	44.2
4796H72	C718H0 x 3761,2	19.8	32.7
4775B	2775-5,16,...aa x A	16.2	20.9
4776B	2776-9,11,...aa x A	14.1	25.3
4777B	2777-7,10,...aa x A	7.5	20.2
4775	YRS 2775Claa x A	18.2	30.2
4776	YRS 2776Claa x A	24.4	39.6
4777	YRS 2777Claa x A	6.3	18.9
4792A	YRS 2792A	28.0	29.2
4793	YRS 2793aa x A	1.8	9.6
4794	YRS 2794aa x A	22.1	35.3
4795A	YRS 2795A	13.3	35.0
4797A	YRS 2797A	17.5	30.4
4798	YRS 2798aa x A	14.3	22.5
3705H3	F66-562H0 x C706	16.4	25.6
3705H72B	C718H0 x C706	7.7	28.5
3718H3 Sp	F66-562H0 x C718	13.6	38.6
3718H4	F66-563H0 x C718	14.8	39.8
3546H54	C706H0 x F70-546	18.3	23.1
F70-546H3	562H0 x F63-546	14.4	35.5
4788	YRS 2788	13.9	16.7
3705	Inc. C706	27.5	35.3
3705H0	C706H0 x C706	25.0	40.0
3718 Sp	Inc. C718	22.0	37.4
3718H0B Sp	C718H0 x C718	21.0	46.2
F74-718	Inc. C718	15.3	38.5
F74-718H0	C718H0 x C718	7.4	23.5
4280	3279mm ⊗	2.2	7.6
4281	3280mm ⊗	9.5	21.1
3791C1	2791mm ⊗	24.7	36.1

TEST 475. BOLTING EVALUATION TEST, SALINAS, CALIFORNIA, 1975 cont.

Variety	Description	7/9 Bolting Percent	8/25 Bolting Percent
3791(TO)C1	T-O Sel. 2791mm ⊗	42.9	53.8
4791C1mm	2791-HS, HGSmm ⊗	19.3	28.6
4755B	YRS 2755-1,2,...	28.2	36.5
4708	YRS 2708 ⊗	4.6	11.8
4709	YRS 2709 ⊗	56.7	63.7
4710	YRS 2710 ⊗	36.5	43.1
4713	YRS 2713 ⊗	22.6	37.9
4730	YRS 2730 ⊗	24.5	39.5
4731	YRS 2731 ⊗	8.9	25.0
4733	YRS 2733 ⊗	11.8	23.0
4736	YRS 2736 ⊗	0.0	2.2
4737	YRS 2737 ⊗	7.1	16.7
4758-1	YRS 2758-1 ⊗	2.1	6.8
4758-3	YRS 2758-3 ⊗	6.5	14.8
4758-4	YRS 2758-4 ⊗	75.0	91.7
4769	YRS 2769 ⊗	79.6	89.5
4778	YRS 2778 ⊗	65.6	77.5
4779	YRS 2779 ⊗	17.1	34.4
4780	YRS 2780 ⊗	3.9	24.5
4781	YRS 2781 ⊗	12.0	21.4
4783	YRS 2783 ⊗	22.6	26.1
4784	YRS 2784 ⊗	2.7	5.3
4786	YRS 2786 ⊗	22.1	30.1
4770	YRS 2770 ⊗	16.1	23.0
4774	YRS 2774 ⊗	3.6	10.0
6600	Inc. C5600	100.0	100.0
3600	Inc. 6600	100.0	100.0
8500	Inc. 1460	100.0	100.0
8500HO	1460HO x 1460	100.0	100.0
9760	Inc. 7760C2	65.6	67.7
9760HO	7760HO x 7760	75.5	82.7
2512	Inc. 1512-1	0.0	0.0
4229	BMRS 3229 ⊗	1.1	8.6
4230	BMRS 3230 ⊗	4.6	8.0
4231	BMRS 3231 ⊗	35.8	63.0
4232	BMRS 3232 ⊗	53.9	54.9
4233	BMRS 3233 ⊗	88.9	98.7
4234	BMRS 3234 ⊗	100.0	100.0
4235	BMRS 3235 ⊗	62.7	65.1
4236	BMRS 3236 ⊗	24.2	32.0
4237,8	BMRS 3237,8 ⊗	17.3	31.7
4239	BMRS 3239 ⊗	72.4	78.1
4240	BMRS 3240 ⊗	28.3	36.5
4241	BMRS 3241 ⊗	6.1	22.8
4242	BMRS 3242 ⊗	27.7	32.1
4245	BMRS 3247 ⊗	84.7	86.2
4717	Inc. 3232	28.2	30.7

TEST 875. BOLTING EVALUATION TEST, SALINAS, CALIFORNIA, 1975

4 replications
1-row plots, 32 ft. long

Planted: November 22, 1974
Harvested: September 15-16, 1975

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	7/9 Bolting Percent	8/25 Bolting Percent	Beets/ 100' Number	Root Rot %
Y333H80	(C564H0 x C718) x Y233	14,940	49.58	15.1	4.7	12.2	147	2.2
E402H8	546H3 x E302	14,390	46.68	15.4	11.9	23.5	156	2.8
Y401H72	C718H0 x Y201(C01)	14,230	46.05	15.5	14.5	33.5	157	1.6
US H10B	546H3 x F70-17(1068)	13,500	44.11	15.3	16.1	22.7	161	1.5
Y402H31	(C562H0 x C718) x Y201(C01)	13,180	43.56	15.2	15.2	26.3	155	3.1
4717H31	(C562H0 x C718) x 3232	13,180	43.84	15.0	30.4	40.3	157	0.0
417H8	546H3 x 813(C17)	12,730	42.80	15.0	12.5	21.6	151	2.5
E434H8	546H3 x ERS C413	12,460	41.34	15.1	15.1	27.2	155	0.0
4717H8	546H3 x 3232	12,300	40.79	15.1	33.0	40.1	124	1.1
E406H8	546H3 x E406	11,870	39.75	14.9	17.9	24.3	165	0.9
Mean		13,279	43.85	15.16	17.1	27.2	153	1.6
LSD (.05)		1,192	3.96	NS	7.3	9.7	20.3	NS
Coefficient of Variation (%)		6.2	6.2	3.4	29.5	24.5	9.2	120.3
F value		5.9**	4.7**	NS	11.3**	6.8**	2.6*	NS
Y417H72	C718H0 x Y317	16,330	51.45	15.9	1.9	11.9	137	0.6
Y419H72	C718H0 x Y319	16,080	51.18	15.7	3.2	18.0	138	1.2
Y420H72	C718H0 x Y320	16,080	52.22	15.4	2.7	9.5	141	1.7
Y418H72	C718H0 x Y318	15,030	49.72	15.2	2.5	18.3	128	2.8
Y418H8	546H3 x Y318	15,000	48.34	15.5	4.8	16.6	138	1.9
Y419H8	546H3 x Y319	14,630	46.33	15.8	5.1	12.0	134	3.2
Y420H8	546H3 x Y320	14,560	46.54	15.7	5.4	11.3	142	2.3
Y418H3	C562H0 x Y318	14,180	46.54	15.3	8.8	17.5	134	2.4
Y417H3	C562H0 x Y317	13,860	45.77	15.1	7.4	23.8	127	0.6
Y418	Inc. Y318	13,170	43.42	15.2	7.6	13.3	143	2.4

TEST 875. BOLTING EVALUATION TEST, SALINAS, CALIFORNIA, 1975 continued

Variety	Description	Acre Yield		Sucrose	7/9 Bolting	8/25 Bolting	Beets/ 100'	Root Rot
		Sugar Pounds	Beets Tons	Percent	Percent	Percent	Number	%
Y419HO	Y319H2 x Y319	13,060	40.86	16.0	5.4	16.2	140	0.5
Y418HO	Y318H2 x Y318	12,940	42.80	15.1	12.1	25.3	138	3.2
Y420HO	Y320H2 x Y320	12,840	41.14	15.6	4.3	5.9	130	0.9
013A	Inc. 413A	12,720	42.80	14.9	15.2	31.8	138	0.5
Y419	Inc. Y319	12,510	38.71	16.2	1.7	5.9	138	2.2
E435	ERS C413	12,490	40.17	15.6	15.3	16.7	143	0.5
Y422	YRS Y222A(C22)	12,480	39.96	15.6	14.7	27.4	146	0.5
Y442	Inc. 3256	12,470	41.27	15.1	21.2	31.9	131	5.2
417(Sp.)	Inc. 813(C17)	12,330	40.79	15.1	11.1	23.5	125	2.7
Y401A	YRS Y201(C01)	12,260	38.50	15.9	21.8	41.2	134	2.1
Y331	Inc. Y231(C31)	12,220	38.02	16.1	9.2	16.7	137	3.4
Y333	Inc. Y233	12,210	40.79	15.0	5.3	17.1	134	2.9
417(Ore.)	Inc. 713A(C17)	12,200	40.72	15.0	5.8	12.6	141	6.0
F70-13	Inc. F66-13	12,180	40.44	15.0	23.6	35.2	139	4.2
Y439	Inc. Y339	12,120	38.78	15.7	31.0	45.4	134	3.2
Y420	Inc. Y320	11,990	38.23	15.7	4.4	8.1	132	1.2
E434	ERS C413	11,970	39.82	15.0	19.2	25.6	133	2.1
Y423	YRS Y123	11,970	39.27	15.3	17.2	34.7	137	0.7
Y441	Inc. 3255	11,810	39.40	15.0	38.0	53.0	139	3.1
4789	3789aa x A	11,710	37.67	15.6	15.1	28.1	139	3.1
Y430	YRS Y230A,B	11,500	37.88	15.2	25.8	36.2	138	3.6
E406	ERS E306	11,440	37.26	15.4	19.6	34.6	137	1.3
Y417	Inc. Y317	11,130	37.53	14.8	16.5	26.2	128	1.0
Y440	Inc. 3254	11,090	35.66	15.5	10.4	21.0	128	10.6
4755	2755aa x A	11,070	36.70	15.1	23.6	27.9	147	0.6
4790	3790aa x A	11,030	35.87	15.4	16.0	25.0	145	1.5
E402	ERS E302	10,690	36.36	14.7	23.9	28.7	130	1.5
4740	2775,6Claa x A	10,670	35.11	15.2	27.2	38.3	141	2.2
Y417HO	Y317H2 x Y317	10,590	35.60	14.9	12.9	19.8	134	3.7

TEST 875. BOLTING EVALUATION TEST, SALINAS, CALIFORNIA, 1975 continued

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	7/9 Bolting Percent	8/25 Bolting Percent	Beets/ 100' Number	Root Rot %
Y426	YRS Y126	9,940	31.86	15.6	49.1	72.7	147	1.5
4741	2792,3,4,5aa x A	9,750	31.44	15.5	21.3	33.2	130	0.6
4717	Inc. 3232	7,540	25.14	15.0	30.9	32.5	112	2.1
Mean		12,424	40.43	15.36	14.7	25.0	136	2.3
LSD (.05)		1,191	3.76	0.69	7.8	8.8	NS	3.7
Coefficient of Variation (%)		6.8	6.6	3.2	37.6	25.2	16.7	113.1
F value		17.4**	17.0**	2.2**	14.9**	17.6**	NS	2.0**
4791	2791-HGSaa x A	12,150	38.99	15.6	9.5	20.1	130	0.6
3791	2791aa x A	11,940	39.06	15.3	23.7	34.2	120	1.4
4791E	2791-LSaa x A	11,780	38.16	15.5	15.1	32.6	122	1.3
4791B	YRS 2791	10,930	34.63	15.8	15.6	24.1	131	1.8
4791C	2791-LGSaa x A	10,730	34.69	15.5	17.7	32.3	127	0.7
4791D	2791-HSaa x A	10,640	34.07	15.6	15.5	35.2	123	0.0
Mean		11,362	36.60	15.55	16.2	29.8	125	1.0
LSD (.05)		1,155	3.98	NS	NS	10.5	NS	NS
Coefficient of Variation (%)		6.7	7.2	1.6	33.7	23.4	6.6	150.8
F value		3.1*	3.2*	NS	NS	3.1*	NS	NS
4791EH8	546H3 x 2791-LS	12,720	39.68	16.0	9.9	27.6	147	1.6
4791H8	546H3 x 2791-HGS	12,470	39.13	16.0	9.6	20.4	156	1.0
3791H8	546H3 x 2791	12,040	37.95	15.9	12.9	25.4	158	1.6
4791BH8	546H3 x YRS 2791	11,900	37.95	15.7	10.8	22.9	162	1.7
4791DH8	546H3 x 2791-HS	11,900	38.02	15.7	7.0	17.9	159	0.4
4791CH8	546H3 x 2791-LGS	11,740	36.36	16.2	11.6	18.7	160	0.0
Mean		12,129	38.18	15.91	10.3	22.2	157	1.0
LSD (.05)		NS	NS	NS	NS	NS	NS	NS
Coefficient of Variation (%)		8.1	6.5	2.5	36.7	28.2	5.1	166.7
F value		NS	NS	NS	NS	NS	NS	NS

TEST 975. BOLTING AND YIELD EVALUATION TEST, SALINAS, CALIFORNIA, 1975

5 replications — Planted: November 23, 1974

1-row plots, 53 ft. long — Harvested: September 15-16, 1975

Variety	Description	Acre Yield		Sucrose	7/9 Bolting	8/25 Bolting	Root Rot	Beets/ 100'
		Sugar	Beets					
		Pounds	Tons	Percent	Percent	Percent	Percent	Number
417H72	C718HO x 813 (C17)	14,630	48.18	15.2	6.6	18.8	2.9	116
Y401H29	(C718HO x C536) x Y201 (C01)	14,480	46.94	15.4	9.7	24.9	2.2	138
417H29	(C718HO x C536) x 813 (C17)	14,380	46.97	15.3	5.3	15.6	2.1	136
417H27	(C718HO x C565) x 813 (C17)	14,320	47.81	15.0	5.8	16.8	0.5	136
Y401H33	(C718HO x C546) x Y201 (C01)	14,300	46.50	15.4	19.0	39.4	0.6	128
417H26	(536H1 x C564) x 813 (C17)	14,000	44.89	15.5	8.4	20.4	0.6	131
Y401H31	(C562HO x C718) x Y201 (C01)	13,900	45.43	15.3	20.7	38.5	1.1	128
Y322H80	(C564HO x C718) x Y222A (C22)	13,860	44.96	15.4	6.1	21.7	0.8	110
417H28	(C562HO x C536) x 813 (C17)	13,750	44.92	15.3	5.5	13.1	3.2	132
417H33	(C718HO x C546) x 813 (C17)	13,670	46.40	14.7	9.4	20.8	0.8	139
US H10B	546H3 x F70-17 (1068)	13,640	45.39	15.0	11.6	21.7	0.3	144
417H25	(522H1 x C564) x 813 (C17)	13,500	44.89	15.1	7.0	16.9	4.2	112
Y331H80	(C564HO x C718) x Y231 (C31)	13,400	44.29	15.1	7.4	17.3	3.0	120
464H8	F70-546H3 x F66-64	13,400	42.84	15.6	7.0	11.9	0.9	133
Y441H8	546H3 x 3255	13,370	42.87	15.6	22.0	32.8	1.7	138
Y440H29	(C718HO x C536) x 3254	13,350	44.52	15.0	7.6	16.0	1.7	147
Y417H31	(C562HO x C718) x Y317	13,350	44.89	14.9	12.7	33.1	2.7	116
Y442H8	546H3 x 3256	13,310	42.87	15.5	15.1	34.8	1.6	120
417H31	(C562HO x C718) x 813 (C17)	13,240	44.49	14.9	8.9	24.0	5.1	110
Y439H8	546H3 x Y339	13,070	42.13	15.5	22.4	36.5	0.5	140
Y440H8	546H3 x 3254	13,030	41.93	15.5	11.2	20.9	1.1	144
417H21	C536HO x 813 (C17)	12,890	43.21	14.9	5.2	12.2	1.9	124
Y401H8	F70-546H3 x Y201 (C01)	12,880	40.29	16.0	19.9	36.8	1.7	108
Y417H8	F70-546H3 x Y317	12,670	41.90	15.1	11.8	22.2	1.0	118
464H2	(502HO x 547) x F66-64	12,600	40.93	15.4	9.3	19.8	3.1	115
417H3	F66-562HO x 813 (C17)	12,410	40.05	15.5	7.0	21.8	1.5	94
4791H80	(C564HO x C718) x 2791-HGS	11,310	37.60	15.0	8.7	27.7	0.6	131
4791DH80	(C564HO x C718) x 2791-HS	11,210	37.63	14.9	15.0	28.5	0.8	132
Mean		13,350	43.78	15.25	10.9	23.7	1.7	126
LSD (.05)		1,071	3.33	0.55	5.6	7.9	2.4	16
Coefficient of Variation (%)		6.4	6.1	2.9	41.2	26.6	110.5	10
F value		4.7**	5.4**	2.3**	7.2**	8.6**	2.0**	5**

** Exceeds the 1% point of significance (F = 1.9).

TEST 1075. DIPLOID-TRIPLOID TEST, SALINAS, CALIFORNIA, 1975

10 replications
2 row plots, 53 ft. long

Planted: December 18, 1974
Harvested: September 17-18, 1975

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	7/22 Bolting Percent	8/25 Bolting Percent	Root Rot Percent	Beets/ 100' Number
417H8	F70-546H3 x 813	12,210ab	37.25ab	16.4	9.9d	15.7d	2.3a	125c
417TH8	F70-546H3 x 117T	12,470a	38.14a	16.4	6.2c	13.2cd	6.7bcd	120d
417H21	3536-97H0 x 813	12,250ab	37.23ab	16.5	4.3abc	11.2bc	5.2abc	127bc
417TH21	3536-97H0 x 117T	12,160ab	38.51a	15.8	4.5abc	8.5ab	15.8e	124cd
417H28	3536-97H3 x 813	12,590a	38.15a	16.5	5.7bc	10.5bc	5.8abc	130ab
417TH28	3536-97H3 x 117T	12,720a	38.95a	16.4	3.6ab	8.6ab	10.2d	127abc
417H29	3536-97H72 x 813	12,430a	38.51a	16.1	6.1c	11.7bc	7.6cd	130ab
417TH29	3536-97H72 x 117T	12,440a	39.00a	16.0	3.0a	6.8a	16.0e	124cd
US H10B	117H8 (Lot 1068)	11,680b	35.91b	16.3	15.5e	22.4e	3.3ab	131a
Mean		12,330	37.96	16.3	6.5	12.1	8.1	126
LSD (.05)		585	1.95	NS	2.02	2.96	3.38	4.07
Coefficient of Variation (%)		5.3	5.8	4.4	34.7	27.6	46.8	3.6
F value		2.11*	2.09*	1.14	29.82**	20.07**	17.10**	6.78**

*Exceeds the 5% point of significance (F = 2.07).
**Exceeds the 1% point of significance (F = 2.77).

Means with a letter in common are not significantly different at the 5% level.

TEST 1175. HYBRID TEST, SALINAS, CALIFORNIA, 1975

10 replications
2-row plots, 53 ft. long

Planted: December 18, 1974
Harvested: September 29-30, 1975

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose %	Bolting %	Root Rot %	Beets/ 100' Number
417H27	(C718H0 x C565) x 813 (C17)	14,370	45.55	15.8	15.1	7.6	123
417H72	C718H0 x 813 (C17)	14,260	45.42	15.7	13.8	8.2	121
Y401H72	C718H0 x Y201 (C01)	14,040	44.82	15.7	24.5	5.8	122
Y401H33	(C718H0 x C546) x Y201 (C01)	13,720	43.11	15.9	23.3	1.4	130
Y417H72	C718H0 x Y317	13,700	45.15	15.2	16.4	8.3	118
Y401H31	(C562H0 x C718) x Y201 (C01)	13,680	43.26	15.8	24.2	3.8	129
417H33	(C718H0 x C546) x 813 (C17)	13,650	44.30	15.4	13.6	5.1	122
Y401H29	(C718H0 x C536) x Y201 (C01)	13,630	42.00	16.2	20.4	6.2	128
Y440H29	(C718H0 x C536) x 3254	13,550	43.07	15.7	12.7	5.0	127
417H29	(C718H0 x C536) x 813 (C17)	13,460	42.95	15.6	12.3	10.8	123
Y417H3	F66-562H0 x Y317	13,460	42.07	16.0	14.8	10.7	127
417H31	(C562H0 x C718) x 813 (C17)	13,430	42.85	15.7	18.0	5.9	123
417H25	(522H1 x C564) x 813 (C17)	13,300	43.75	15.2	16.6	7.3	116
417H26	(536H1 x C564) x 813 (C17)	13,050	42.15	15.5	18.4	7.0	127
Y417H31	(C562H0 x C718) x Y317	12,900	42.09	15.3	19.5	7.6	123
US H10B	546H3 x F70-17 (1068)	12,860	40.88	15.7	23.3	3.6	126
417H3	F66-562H0 x 813 (C17)	12,750	40.69	15.7	15.4	7.5	123
E402,6H8	546H3 x E302, E306	12,630	41.13	15.3	19.3	1.2	123
Mean		13,468	43.07	15.63	17.9	6.3	124
LSD (.05)		725	1.66	0.52	3.4	2.4	6.2
Coefficient of Variation (%)		6.1	4.4	3.8	21.6	42.5	5.6
F value		3.6**	6.5**	2.2**	10.8**	9.9**	2.8**

**Exceeds the 1% point of significance (F = 2.1).

TEST 1275. HYBRID X VIRUS YELLOWS TEST, SALINAS, CALIFORNIA, 1975

7 replications
2 virus treatments
1-row plots, 37 ft. long

Planted: December 19, 1974
Inoculated with BYV-BWYV: May 22, 1975
Harvested: October 6-8, 1975

Variety	Description	Sugar Yield (lb/A) Check	Inoc.	% Loss	Beet Yield (Tons/A) Check	Inoc.	% Loss
Y418H72	C718HO x Y318	13,810	10,370	24.6	44.74	37.61	15.9
Y419H72	C718HO x Y319	13,760	10,760	21.4	42.93	36.41	15.2
Y401H8	F70-546H3 x Y201(C01)	13,370	9,870	26.1	41.73	33.33	20.1
Y420H72	C718HO x Y320	13,290	10,020	24.2	43.34	35.31	18.3
E402H8	546H3 x E302	13,080	8,920	31.6	41.45	31.54	23.8
Y441H8	546H3 x 3255	12,990	8,600	33.5	40.42	30.14	25.3
Y402H31	(C562HO x C718) x 2216	12,940	9,370	27.3	41.31	33.05	19.5
417H82	(C706HO x C718) x 813(C17)	12,850	9,480	26.0	41.21	33.12	19.5
Y439H8	546H3 x Y339	12,850	8,680	32.0	39.26	30.31	22.7
Y440H8	546H3 x 3254	12,790	9,080	29.1	40.59	31.82	21.5
Y442H8	546H3 x 3256	12,700	9,040	28.6	38.98	31.89	18.0
464H2	(502HO x 547) x F66-64	12,640	8,200	34.9	38.98	29.04	25.3
464H8	F70-546H3 x F66-64	12,540	8,500	32.3	38.54	30.38	21.2
Y401H34	(C706HO x C546) x Y201(C01)	12,370	10,050	18.4	38.43	33.36	13.0
417H35	(C562HO x C706) x 813(C17)	12,330	8,980	26.9	38.74	31.06	19.5
Y401H30	(C706HO x C536) x Y201(C01)	12,290	9,310	24.0	38.47	31.85	16.9
Y417H8	F70-546H3 x Y317	12,170	9,490	21.8	38.64	31.65	17.8
US H10B	546H3 x F70-17(1068)	11,860	8,990	23.9	38.19	31.30	17.9
E434H8	546H3 x ERS C413	11,850	8,860	25.0	37.78	30.75	18.5
4717H8	F70-546H3 x 3232	11,720	8,000	31.7	38.06	28.46	25.2
417H30	(C706HO x C536) x 813(C17)	11,700	9,070	22.3	37.58	31.54	15.9
417H34	(C706HO x C546) x 813(C17)	11,650	9,480	18.6	37.03	32.43	12.3
4717H31	(C562HO x C718) x 3232	11,190	8,700	21.9	36.31	30.51	16.0
E406H8	546H3 x E306	10,860	8,120	25.1	35.14	29.62	15.7
Mean		12,480[a]	9,160[b]	26.3	39.49[a]	31.94[b]	19.0
LSD (.05)		910	820	7.9	2.48	2.43	7.2
Coefficient of Variation (%)		6.9	8.4	28.3	5.9	7.2	36.1
F value		5.5**	5.7**	2.7**	6.8**	6.3**	2.0**

Significant variety x virus interactions occurred for sugar yield, beet yield, and % sucrose at the .01, .05, and .05 levels, respectively.
Paired means with a letter in common are not significantly different.
**, * Exceeds the 1% (F = 1.9) and 5% (F = 1.6) points of significance.

TEST 1275. HYBRID X VIRUS YELLOWS TEST, SALINAS, CALIFORNIA, 1975, cont.

Variety	Description	% Sucrose			Beets/ 100' Number	% Bolt.	Root Rot %
		Check	Inoc.	Loss			
Y418H72	C718HO x Y318	15.4	13.8	1.7	111	6.5	4.3
Y419H72	C718HO x Y319	16.0	14.8	1.2	119	6.2	2.8
Y401H8	F70-546H3 x Y201(C01)	16.0	14.8	1.2	129	19.3	0.3
Y420H72	C718HO x Y320	15.3	14.2	1.1	120	4.0	3.4
E402H8	546H3 x E302	15.8	14.2	1.7	131	12.8	0.9
Y441H8	546H3 x 3255	16.1	14.3	1.8	128	21.8	0.4
Y402H31	(C562HO x C718) x 2216	15.7	14.1	1.5	132	19.0	1.9
417H82	(C706HO x C718) x 813(C17)	15.6	14.3	1.3	132	9.0	2.9
Y439H8	546H3 x Y339	16.3	14.3	2.0	136	16.8	1.6
Y440H8	546H3 x 3254	15.8	14.3	1.5	128	11.5	0.9
Y442H8	546H3 x 3256	16.3	14.2	2.1	124	13.1	1.2
464H2	(502HO x 547) x F66-64	16.2	14.1	2.1	119	9.7	1.0
464H8	F70-546H3 x F66-64	16.3	14.0	2.3	125	7.2	0.5
Y401H34	(C706HO x C546) x Y201(C01)	16.1	15.0	1.1	127	18.2	0.7
417H35	(C562HO x C706) x 813(C17)	15.9	14.5	1.5	133	10.3	2.4
Y401H30	(C706HO x C536) x Y201(C01)	16.0	14.6	1.4	130	19.1	3.6
Y417H8	F70-546H3 x Y317	15.7	15.0	0.8	123	11.4	3.0
US H10B	546H3 x F70-17(1068)	15.5	14.4	1.2	131	18.4	1.7
E434H8	546H3 x ERS C413	15.7	14.4	1.4	128	15.8	0.4
4717H8	F70-546H3 x 3232	15.4	14.1	1.4	116	33.4	1.7
417H30	(C706HO x C536) x 813(C17)	15.6	14.4	1.2	133	6.9	6.1
417H34	(C706HO x C546) x 813(C17)	15.7	14.6	1.2	129	9.7	2.2
4717H31	(C562HO x C718) x 3232	15.4	14.2	1.3	123	33.0	0.3
E406H8	546H3 x E306	15.5	13.7	1.8	124	27.9	0.5
Mean		15.80[a]	14.33[b]	1.5	126	15.0	1.9
LSD (.05)		0.59	0.61	0.8	7	3.9	1.7
Coefficient of Variation (%)		3.5	4.0	50.5	7	34.6	125
F value		2.2**	2.4**	1.8*	6**	33.5**	5.6**

Significant variety x virus interactions occurred for sugar yield, beet yield, and % sucrose at the .01, .05, and .05 levels, respectively.
Paired means with a letter in common are not significantly different.
**, * Exceeds the 1% (F = 1.9) and 5% (F = 1.6) points of significance.

TEST 1375. YELLOWS AND COMBINING ABILITY EVALUATION OF 791 POPULATIONS, SALINAS, CALIFORNIA, 1975

7 replications
2 virus treatments
1-row plots, 37 ft. long

Planted: December 19, 1974
Inoculated with BYV-BWYV: May 22, 1975
Harvested: October 1-2, 1975

Variety	Description	Sugar Yield (lbs/A)			Beet Yield (tons/A)			% Sucrose			Beets/ 100'	%
		Check	Inoc.	% Loss	Check	Inoc.	% Loss	Check	Inoc.	Loss	Number	Bolting
464	Inc. F66-64	12,160	7,930	34.3	38.16	29.14	23.0	15.9	13.6	2.3	124	11.3
4791	2791-HGSaa x A	11,400	8,810	22.6	36.03	30.34	15.8	15.8	14.5	1.3	116	21.8
4791E	2791-LSaa x A	10,970	8,400	23.2	35.11	29.01	17.1	15.6	14.5	1.1	122	24.6
4791D	2791-HSaa x A	10,960	8,240	24.7	33.77	28.42	15.7	16.2	14.5	1.8	119	21.8
F71-17	Inc. F70-17	10,780	8,590	20.5	35.69	30.24	15.4	15.1	14.2	0.9	116	15.9
3791	2791aa x A	10,680	7,900	25.9	34.25	27.84	18.4	15.6	14.2	1.4	119	27.7
4791B	YRS 2791	10,680	7,730	27.5	33.12	26.33	20.4	16.1	14.7	1.4	118	23.3
4791C	2791-LGSaa x A	10,550	8,200	22.0	32.95	28.53	13.2	16.0	14.4	1.6	119	18.6
2791	1792,3,7,8aa x A	10,240	7,900	22.7	32.57	27.67	14.9	15.7	14.3	1.5	120	36.0
Mean		10,936[a]	8,189[b]	24.8	34.63[a]	28.61[b]	17.1	15.79[a]	14.3[b]	1.5	119	22.3
LSD (.05)		768	636	7.2	2.23	1.86	NS	0.52	0.47	0.6	NS	4.6
Coefficient of Variation (%)		6.5	7.2	27.2	6.0	6.0	39.3	3.0	3.1	37.0	6	27.7
F value		4.3**	2.6*	2.6*	5.3**	3.8**	NS	3.4**	3.6**	3.6**	NS	18.3**
464H8	546H3 x F66-64	13,650	8,580	37.0	41.97	31.06	25.8	16.3	13.8	2.5	134	8.7
US H10B	546H3 x F70-17(1068)	12,170	8,870	27.2	39.67	32.16	19.0	15.3	13.8	1.6	129	19.2
4791EH8	546H3 x 2791-LS	11,550	7,830	32.1	36.45	28.32	22.3	15.9	13.8	2.0	122	18.3
4791BH8	546H3 x YRS 2791	11,550	8,420	27.1	36.27	29.07	19.8	15.9	14.5	1.5	124	21.3
4791DH8	546H3 x 2791-HS	11,350	7,740	31.8	35.18	27.91	20.6	16.1	13.8	2.3	122	17.3
4791H8	546H3 x 2791-HGS	11,150	7,950	28.3	35.69	28.32	20.4	15.6	14.0	1.6	126	17.6
4791CH8	546H3 x 2791-LGS	11,110	8,020	27.7	34.94	28.01	19.6	15.9	14.3	1.6	127	17.3
4791H80	718H5 x 2791-HGS	11,000	7,530	31.4	35.73	27.63	22.7	15.4	13.6	1.8	117	15.4
3791H8	546H3 x 2791	10,990	7,740	29.3	34.97	27.39	21.3	15.7	14.1	1.6	128	22.5
4791DH80	718H5 x 2791-HS	10,880	7,690	28.9	34.94	28.05	19.4	15.6	13.7	1.9	118	16.1
2791H8	546H3 x 1792,3,7,8	10,460	6,930	33.6	32.81	25.30	22.6	15.9	13.7	2.3	111	30.2
3791H80	718H5 x 2791	10,440	6,790	34.8	33.84	25.10	25.8	15.4	13.5	1.9	113	17.9
Mean		11,357[a]	7,841[b]	30.8	36.04[a]	28.19[b]	21.6	15.75[a]	13.88[b]	1.9	123	18.5
LSD (.05)		752	668	NS	2.20	2.01	NS	0.41	0.47	0.6	8	4.4
Coefficient of Variation (%)		6.2	8.0	22.3	5.7	6.7	28.9	2.4	3.1	30.7	9	31.7
F value		10.6**	6.6**	NS	10.3**	7.9**	NS	4.3**	3.1**	2.3*	5**	10.3**

Significant variety x virus interactions occurred for sugar yield and % sucrose at the .01 level for both tests.

TEST 1475. O. P. VARIETY X VIRUS YELLOWS TEST, SALINAS, CALIFORNIA, 1975

7 replications
2 virus treatments
1-row plots, 37 ft. long

Planted: December 20, 1974
Inoculated with BYV-BWYV: May 22, 1975
Harvested: September 22-24, 1975

		Sugar Yield (lb/A)			Beet Yield (Tons/A)		
Variety	Description	Check	Inoc.	% Loss	Check	Inoc.	% Loss
Y442	Inc. 3256	11,830	8,950	23.6	39.09	32.61	16.1
Vytomo		11,440	9,030	20.7	34.87	30.65	11.9
Y422	YRS Y222A(C22)	11,400	8,860	23.1	36.72	31.27	14.8
US H10B	546H3 x F70-17(1068)	11,340	8,610	23.6	36.51	30.14	17.8
Y423	YRS Y123	10,910	7,840	28.0	34.56	28.01	18.9
Y440	Inc. 3254	10,780	7,660	28.4	34.25	28.63	15.9
Y401A	YRS Y201(C01)	10,720	9,180	14.1	33.22	31.03	8.8
E434	ERS F70-13(RR)	10,480	7,690	25.9	34.63	27.57	19.6
Y441	Inc. 3255	10,480	8,330	20.1	34.83	29.52	15.1
Y439	Inc. Y339	10,420	7,720	25.2	33.94	28.22	16.2
Y430	YRS Y230	10,420	7,470	27.9	34.39	27.81	18.5
013A	Inc. 413A	10,270	7,420	27.7	34.63	28.29	18.0
Y426	YRS Y126	10,200	7,720	24.1	30.86	26.95	12.9
464	Inc. F66-64	9,990	7,130	28.6	32.95	26.16	20.4
468	Inc. 868(US 75)	9,910	6,360	35.6	32.40	24.24	25.2
E435	ERS F70-13	9,880	7,870	19.5	32.81	28.39	13.0
E406	ERS E302(RR 67)	9,820	7,430	24.0	31.75	26.85	15.0
417-1	BRS 813	9,650	7,930	17.0	33.22	29.04	13.2
417(Ore)	Inc. 713A(C17)	9,460	7,700	18.6	32.06	27.39	14.2
F70-13	Inc. F66-13(0268)	9,390	6,900	26.1	32.78	26.78	17.9
Y417H0	Y317H2 x Y317	9,130	7,410	18.1	29.93	26.50	11.1
417(Sp)	Inc. 813(C17)	9,080	8,130	10.5	31.44	29.38	7.3
E402	ERS E302(RR 9)	8,950	7,020	21.1	30.65	25.68	15.7
Y416	YRS Y116	8,830	7,510	15.0	29.76	26.95	9.4
Y417	Inc. Y317	8,790	6,620	25.1	29.79	23.97	19.6
4717	Inc. 3232	7,440	4,890	33.5	25.03	18.96	23.5
Mean		10,038[a]	7,668[b]	23.3	32.96[a]	27.73[b]	15.8
LSD (.05)		941	792	10.2	2.65	2.30	9.2
Coefficient of Variation (%)		8.9	9.8	41.5	7.6	7.9	55.2
F value		8.8**	10.5**	2.5**	8.5**	11.0**	1.7*

Significant variety x virus interactions occurred for sugar yield, % sucrose, and % root rot at the .01, .05, and .05 levels, respectively.

Paired means with a letter in common are not significantly different.

**, * Exceeds the 1% (F = 1.9) and 5% (F = 1.6) points of significance.

TEST 1475. O. P. VARIETY X VIRUS YELLOWS TEST, SALINAS, CALIFORNIA, 1975 cont.

7 replications
2 virus treatments
1-row plots, 37 ft. long

Planted: December 20, 1974
Inoculated with BYV-BWYV: May 22, 1975
Harvested: September 22-24, 1975

Variety	Description	% Sucrose Check	% Sucrose Inoc.	% Sucrose Loss	Beets/ 100' Number	Bolt. %	Root Rot %
Y442	Inc. 3256	15.1	13.7	1.4	127	17.3	2.3
Vytomo		16.4	14.7	1.7	129	12.9	1.2
Y422	YRS Y222A(C22)	15.5	14.1	1.5	124	16.7	4.6
US H10B	546H3 x F70-17(1068)	15.5	14.2	1.4	126	17.1	1.4
Y423	YRS Y123	15.8	14.0	1.8	120	13.3	0.9
Y440	Inc. 3254	15.7	13.4	2.4	124	9.1	2.4
Y401A	YRS Y201(C01)	16.2	14.8	1.4	116	27.7	1.5
E434	ERS F70-13(RR)	15.1	13.9	1.2	130	7.6	0.6
Y441	Inc. 3255	15.0	14.1	1.0	122	28.2	1.8
Y439	Inc. Y339	15.4	13.7	1.8	123	29.2	1.5
Y430	YRS Y230	15.2	13.4	1.7	121	20.5	3.1
013A	Inc. 413A	14.8	13.1	1.7	122	17.6	1.1
Y426	YRS Y126	16.5	14.3	2.2	120	31.2	0.5
464	Inc. F66-64	15.2	13.6	1.7	123	10.9	1.0
468	Inc. 868(US 75)	15.3	13.1	2.2	116	14.0	3.4
E435	ERS F70-13	15.0	13.9	1.3	122	13.8	0.2
E406	ERS E302(RR 67)	15.5	13.9	1.6	126	13.4	0.0
417-1	BRS 813	14.5	13.6	1.0	123	5.0	7.9
417(Ore)	Inc. 713A(C17)	14.8	14.1	0.8	118	5.8	4.9
F70-13	Inc. F66-13(0268)	14.3	12.9	1.5	116	21.3	2.4
Y417H0	Y317H2 x Y317	15.2	13.9	1.3	120	16.1	4.3
417(Sp)	Inc. 813(C17)	14.5	13.8	0.8	119	8.9	5.7
E402	ERS E302(RR 9)	14.6	13.7	1.0	120	23.3	0.2
Y416	YRS Y116	14.8	13.9	0.9	117	53.0	2.2
Y417	Inc. Y317	14.7	13.7	1.0	116	13.7	3.4
4717	Inc. 3232	14.9	12.9	2.0	113	28.4	1.8
Mean		15.21[a]	13.79[b]	1.5	121	18.3	2.3
LSD (.05)		0.77	0.72	1.0	6	5.0	2.1
Coefficient of Variation (%)		4.8	4.9	61.0	6	37.0	120.1
F value		4.3**	3.5**	1.6*	4**	32.2**	6.6**

Significant variety x virus interactions occurred for sugar yield, % sucrose, and % root rot at the .01, .05, and .05 levels, respectively.

Paired means with a letter in common are not significantly different.

**, * Exceeds the 1% (F = 1.9) and 5% (F = 1.6) points of significance.

TEST 1575. YELLOWS EVALUATION OF MONOGERM COMPOSITE POPULATIONS, SALINAS, CALIFORNIA, 1975

7 replications
2 virus treatments
1-row plots, 37 ft. long

Planted: December 20, 1974
Inoculated with BYV-BWYV: May 22, 1975
Harvested: September 18-19, 1975

Variety	Description	Sugar Yield (lbs/A)			Beet Yield (Tons/A)			% Sucrose			Beets/ 100'	Bolt.	Root Rot
		Check	Inoc.	% Loss	Check	Inoc.	% Loss	Check	Inoc.	Loss	No.	%	%
US H10B	546H3 x F70-17(1068)	12,590	9,230	26.4	39.87	32.40	18.3	15.8	14.2	1.6	126	20.2	0.7
3773	Inc. 1773a-HGS	11,430	9,440	17.1	36.93	32.85	10.9	15.5	14.4	1.1	119	23.5	0.3
4796H72	C718H0 x 3761,2	11,120	8,260	25.0	36.86	30.69	16.2	15.1	13.4	1.6	122	17.7	0.3
4755	2755aa x A	10,500	7,000	33.1	33.53	26.09	21.9	15.6	13.4	2.2	128	31.9	0.5
417	Inc. 713A	10,400	9,170	11.5	34.97	32.26	7.9	14.9	14.2	0.7	122	8.5	2.1
4790H2B	3790H72 x 3790	10,380	7,570	26.6	33.19	27.33	17.4	15.6	13.8	1.8	122	15.8	0.8
4789H2B	3789H72 x 3789	10,360	7,800	24.3	32.19	27.74	13.5	16.1	14.0	2.1	125	21.7	0.8
4740	2775,6Claa x A	10,010	7,290	27.1	31.65	25.89	18.3	15.8	14.0	1.8	125	21.5	0.9
4741	2792,3,4,5aa x A	9,220	5,900	35.8	28.87	21.19	26.4	16.0	13.9	2.1	119	24.0	0.5
4755B	YRS 2755-1,2,...,19	7,040	4,760	30.7	23.73	17.28	26.4	14.8	13.8	1.1	118	35.5	1.4
Mean		10,305[a]	7,642[b]	25.8	33.18[a]	27.37[b]	17.7	15.51[a]	13.93[b]	1.6	123	22.0	0.8
LSD (.05)		1,081	881	10.6	2.91	2.64	9.7	0.68	0.55	0.7	6	5.1	NS
Coefficient of Variation (%)		9.8	10.8	38.5	8.2	9.0	51.0	4.1	3.7	42.6	6	30.7	196
F value		14.6**	23.4**	3.7**	19.7**	29.9**	3.2**	3.7**	2.7*	3.6**	2*	18.1**	NS

Significant variety x virus interactions occurred for sugar yield, % sucrose, and % bolting at the .05, .01, and .05 levels, respectively.

Paired means with a letter in common are not significantly different.

**, *Exceeds the 1% (F = 2.8) and 5% (F = 2.0) points of significance, respectively.

TEST 1675. VARIETY EVALUATION TEST, 1975

10 replications
2 row plots, 53 ft. long

Planted: February 27, 1975
Harvested: October 10, 1975

Variety	Description	Acre Yield		Sucrose	Bolting	Root Rot	Beets/ 100'
		Sugar Pounds	Beets Tons	Percent	Percent	Percent	Number
464H8	US H7A	14,770a	45.32b	16.3b	0.0a	1.0a	139bc
417H29	(718H0 x 536-97) x C17	14,700a	47.40a	15.6cde	0.0a	17.0c	138bc
417TH29	(718H0 x 536-97) x 117T	14,550a	47.81a	15.3de	0.0a	37.5d	136c
	US H10B	14,440a	46.31ab	15.6cd	0.0a	9.8b	145ab
649	Uladovsk 752	13,820b	41.45c	16.7b	2.3b	1.7a	125d
645	Ramonsk 036	13,580bc	40.66cd	16.7b	1.4ab	3.0a	124d
638	Mezhotnensk 080	13,560bc	38.61f	17.6a	0.4a	2.7a	120d
464	Pollinator line	13,310bc	42.12c	15.8c	0.0a	0.9a	134c
642	Ramonsk 06	13,110cd	39.72def	16.5b	2.6b	2.7a	126d
	US H20	12,670d	40.45cde	15.7cd	27.4c	3.5a	149a
417	Pollinator line	12,640d	41.66c	15.2e	0.0a	20.1c	134c
417T	Tetra of 417	11,850e	38.82ef	15.3de	0.0a	41.8d	123d
Mean		13,584	42.53	16.0	2.8	11.8	133
LSD (.05)		560	1.57	0.4	--	4.8	6.5
Coefficient of Variation (%)		4.6	4.1	2.7	--	45.9	5.5
F value		21.56**	35.25**	30.37**	--	71.62**	15.90**

**Exceeds the 1% point of significance (F = 2.43).

Powdery Mildew Resistance Evaluation Test
Salinas, California
Planted April 1, 1975

Variety or Code No.	Variety	Grade* 8/28	9/9
417H8	US H10B	4.5	4.8
417TH8	US H10B (3n)	4.3	5.5
417H21	536-97H0 x C17	5.5	6.3
417TH21	536-97H0 x C17 (3n)	5.0	6.3
417H28	536-97H3 x C17	5.0	5.8
417TH28	536-97H3 x C17 (3n)	5.0	5.8
417H29	(718H0 x 536-97) x C17	4.5	5.3
417TH29	(718H0 x 536-97) x C17 (3n)	4.3	5.3
417H26	(536H1 x 565) x C17	5.3	5.8
417H27	(718H0 x 565) x C17	4.3	5.0
464H2	US H6	4.3	4.8
464H8	US H7	4.0	4.0
Am 6	Amalgamated variety	5.3	5.8
Am 7	Amalgamated variety	5.3	6.0
Am 8	Amalgamated variety	5.0	6.0
UI 1	U and I variety	5.0	6.5
EL 1	US H20	4.8	5.5
EL 2	US H21	4.5	5.3
AC 1	American Crystal hybrid	2.8	2.8
AC 2	American Crystal hybrid	2.5	2.8
AC 3	American Crystal hybrid	2.8	3.0
AC 4	American Crystal hybrid	3.3	3.0
AC 5	American Crystal hybrid	3.0	2.5
AC 6	American Crystal hybrid	2.3	3.0
AC 7	American Crystal hybrid	2.0	2.3
AC 8	American Crystal hybrid	2.8	3.0
AC 9	American Crystal hybrid	3.3	3.3
AC 10	American Crystal hybrid	2.3	2.8
AC 11	American Crystal hybrid	3.0	2.8
AC 12	American Crystal hybrid	3.3	4.0
GW 1	Great Western variety	4.5	5.5
4943	Verkhynyacksk 103	3.8	4.5
LSD (5%)		0.7	0.7

*0=No mildew 9=Severe mildew
Average 4 replications.

Powdery Mildew Resistance Evaluation Test
Salinas, California, Planted April 1, 1975

Selection or Variety No.	Description	Grade* 8/28	9/9
F63-569H3	562H0 x 569	4.5	6.5
F66-546H3	562H0 x 546	4.5	6.5
3536-97H54	705H0 x 536-97	5.5	6.5
3536-97H72	718H0 x 536-97	6.5	7.0
3536-97H3	562H0 x 536-97	5.5	6.5
2522-29H23	522-25H0 x 522-29	6.5	7.5
3522-25H85	536H61 x 522-25	6.5	7.0
3565H54	705H0 x 565	4.5	5.0
3718H3	562H0 x 718	4.5	6.0
3546H72B	718H0 x 546	4.0	5.0
4554H1	NB 1 x NB 4	4.0	5.0
8551H4	563H0 x 551	4.0	5.5
417	Pollinator line	4.5	6.0
417T	4n C17	4.5	5.5
464	Pollinator line	2.5	4.5
585	Type O SS	4.0	5.0
915	US 15	2.0	3.5
959	US 56	4.0	6.0
921	Comp. Type O lines	4.5	6.0
Y001	Yel. res. comp.	4.5	5.5
Y003	Yellows res. line	4.0	4.5
Y004	413 x 234	5.0	6.5
633	Bel. polyhybrid 1 mm	4.0	4.0
653	Uladovsk 20 mm	3.0	3.0
655	Yaltushkovsk mm	2.5	3.5
Yugo 367	4n leafspot res.	3.5	5.5
Yugo 378	4n leafspot res.	2.5	4.0
Yugo 258	4n leafspot res.	3.5	5.0
Yugo 401	4n leafspot res.	3.0	4.0
Yugo 89	4n line	2.0	3.0
Yugo 121	4n mm line	2.5	3.0
Vytoma	Swedish var.	3.5	5.0
FC 1	68-9163	4.0	5.0
FC 2	69-9439	3.5	5.0
FC 3	69-9440	3.0	4.0
FC 4	65-9702	4.5	4.5
FC 5	67-9094	4.0	5.0
FC 6	A56-3	4.0	5.0
FC 7	721058A	4.0	4.5
FC 8	64-9305	3.0	4.5
FC 9	741047H	4.0	5.0
FC 10	731097H	4.0	5.5
FC 11	731098H	3.0	4.0
FC 12	731099H	2.5	4.0
FC 13	741026H	4.5	5.5
FC 14	741026H2	4.0	5.0
FC 15	721049H0	3.0	5.0
FC 16	641204H0	4.0	5.0

*0 = No mildew 9 = Severe mildew. Ave. 2 replications

Powdery Mildew Resistance Evaluation Test - Inbred Lines
Salinas, California
Planted April 1, 1975

Inbred No.	Description	Grade* 8/28	9/9
1502	NB 1	6.5	6.5
2512	NB 6	2.5	4.0
2547	NB 5	3.5	4.0
4554	NB 4	3.5	4.0
4539	NB 8	5.5	5.5
4569	mm inbred	3.5	5.5
F70-546	mm inbred	3.0	5.0
F66-562	mm inbred	6.0	6.0
F66-562H0	562 CMS	5.5	5.5
8551	mm inbred	2.5	3.5
3522-25	mm inbred	6.5	6.5
4522-29	mm inbred	7.0	6.5
4536-97	mm inbred	6.5	6.5
4536-97H0	536-97 CMS	6.5	7.0
3718	mm inbred	5.5	5.0

*0 = No mildew 9 = Severe mildew
Ave. 2 replications

Bolting Resistance of US H9 and US H10 Seed Lots
Salinas, California, 1975

5 replications, Randomized blocks — Planted: November 22, 1974
1 row plots, 53 ft. long — Counted: August 25, 1975

Lot No.	Variety	Year of Seed Prod.	Place Grown	Percent Bolters
WC 9188	US H10B	1969	Salem	31.5
WC 1068	US H10B	1971	Salem	23.0
WC 3005	US H10B	1973	Salem	21.3
WC 4014	US H10B	1974	Salem	15.4
WC 4178	US H10B	1974	Salem	13.8
WC 4059	US H10B	1974	Salem	17.7
WC 4135	US H10B	1974	Salem	16.9
WC 4157	US H10B	1974	Salem	19.1
WC 4035	US H10B	1974	Salem	23.7
813H8	US H10B	1968	Salinas	20.5
417H8	US H10B	1974	Salinas	20.0
WC 9034	US H9B	1969	Salem	36.4
Mean				21.6
LSD (.05)				6.5
Coefficient of Variation (%)				28.8
F value				8.0**

**Exceeds the 1% point of significance (F = 3.46).

PERFORMANCE OF NEMATODE WILTING TOLERANT SELECTIONS, SALINAS, CALIFORNIA

10 replication of each variety
1 row plots, 20 feet long

Planted: May 1, 1975
Harvested: October 20, 1975

Under Light Nematode Infestation

Variety[1]	Acre Yield		Sucrose	Harvest Count	Bolting	Wilting Grade[2]	
	Sugar	Beets					
	Pounds	Tons	Percent	Number	Percent	7/31	8/22
270	3,505	11.79	14.9	127	48	1.4	2.2
568	7,109	21.14	16.8	126	0	1.8	3.4
881	7,084	21.14	16.8	138	0	1.3	2.2
US H10B	6,233	19.32	16.1	146	0	2.9	3.7
Mean	5,983	18.35	16.1	Beets		1.86	2.88
LSD (.05)	1,080	2.95	0.73	per		0.85	0.68
C.V. (%)	18.56	16.51	4.64	100'		46.72	24.31
F Value	21.12**	19.46**	13.25**	row		6.02**	11.04**

Under Severe Nematode Infestation

270	3,101	11.08	14.0	125	34	1.9	1.9
568	3,702	11.10	16.7	118	0	3.4	3.4
881	4,980	16.17	15.4	130	0	1.4	1.9
US H10B	2,223	7.33	15.2	127	0	5.5	5.1
Mean	3,502	11.42	15.3	Beets		3.05	3.08
LSD (.05)	540	1.72	0.49	per		0.34	0.38
C.V. (%)	16.81	16.38	3.48	100'		12.31	13.40
F Value	38.68**	37.61**	41.94**	row		240.43**	136.58**

**Exceeds the 1% point of significance (F = 4.60).

Loss in Sugarbeet Varietal Performance When Grown Under Severe Nematode Infestation in Contrast to Performance Under Light Nematode Infestation

Variety	Acre Yield		Sucrose
	Sugar	Beets	
	Percent	Percent	Percent
270	12	6	6.0
568	48	47	0.6
881	30	24	8.3
US H10B	64	62	5.6

[1] Varieties 270, 568 and 881 selected by the Instituut voor Rationele Suikerproductie in the Netherlands for tolerance to wilting caused by the sugarbeet nematode. US H10B is an unselected check.

[2] 1 = No wilting, 10 = Severe wilting.

HYBRID TEST, BRAWLEY, CALIFORNIA, 1974-75

10 replications
2 row plots, 40 ft. long

Planted: September 11, 1974
Harvested: May 13-14, 1975

Variety	Description	Acre Yield		Sucrose	Bolting	Beets/ 100'
		Sugar Pounds	Beets Tons	Percent	Percent	Number
Y402H31	(562H0 x 718) x 2216	9,330	33.26	14.0	12.7	151
Y401H31	(562H0 x 718) x Y201 (C01)	9,280	32.16	14.4	18.7	154
417H72	718H0 x 813 (C17)	9,240	33.31	13.9	8.4	138
Y322H80	(564H0 x 718) x Y222A (C22)	9,240	32.81	14.1	26.2	150
417H27	(718H0 x 565) x 813 (C17)	9,130	32.79	13.9	10.8	143
Y441H8	546H3 x (Y201 x F66-64)	9,070	31.17	14.5	12.5	164
417H31	(562H0 x 718) x 813 (C17)	9,060	32.84	13.8	11.8	151
Y418H8	F70-546H3 x Y318	9,030	31.41	14.4	16.3	143
417H25	(522H1 x 565) x 813 (C17)	9,030	32.27	14.0	5.0	143
Y401H8	F70-546H3 x Y201 (C01)	8,940	30.19	14.8	11.8	146
Y417H31	(562H0 x 718) x Y317	8,940	31.95	14.0	5.7	143
417H26	(536H1 x 565) x 813 (C17)	8,940	31.39	14.2	7.0	149
417H3	F66-562H0 x 813 (C17)	8,910	30.43	14.7	3.8	148
417H33	(718H0 x 546) x 813 (C17)	8,790	31.49	14.0	18.6	153
Y442H8	546H3 x (Y104 x F66-64)	8,750	30.97	14.1	15.2	149
Y440H8	546H3 x (813 x F66-64)	8,740	30.93	14.1	7.5	159
417H82	(705H0 x 718) x 813 (C17)	8,610	30.66	14.0	9.0	141
464H8	F70-546H3 x F66-64	8,500	29.88	14.2	3.5	157
Y417H8	F70-546H3 x Y317	8,410	30.11	14.0	6.2	151
E406H8	546H3 x ERS E306	8,380	29.10	14.4	13.5	153
US H10B	546H3 x C17 (lot 1068)	8,050	28.50	14.1	10.5	149
4791DH80	(564H0 x 718) x 2791 (HS)	7,950	27.39	14.5	7.8	149
Mean		8,830	31.14	14.19	11.0	149
LSD (.05)		499	1.22	0.61	3.7	8
CV (%)		6.4	4.5	4.8	37.9	6.3
F value		4.5**	12.5**	1.6*	17.7**	4.3**

* and ** Exceeds the 5% and 1% points of significance.

OPEN-POLLINATED VARIETY TEST, BRAWLEY, CALIFORNIA, 1974-75

10 replications
1 row plots, 40 ft. long

Planted: September 12, 1974
Harvested: May 16, 1975

Variety	Description	Acre Yield		Sucrose	Bolting	Beets/ 100'
		Sugar Pounds	Beets Tons	Percent	Percent	Number
US H10B	546H3 x C17 (lot 1068)	9,660	29.70	16.3	7.4	148
Y440	F_2(813 x F66-64)	9,450	30.05	15.7	12.0	141
Y442	F_2(Y104 x F66-64)	9,360	29.45	15.9	23.3	144
Y441	F_2(Y201 x F66-64)	9,290	29.48	15.8	26.6	139
423-1	Inc. 023-1	9,260	29.91	15.5	9.4	134
423-2	Inc. 023-2	9,230	28.92	15.9	11.1	126
423-3	Inc. 023-3	9,180	29.63	15.5	15.6	132
464	Inc. F66-64	9,080	27.87	16.3	6.9	146
Y418H0	Y318H2 x Y318	8,940	27.51	16.2	22.3	144
F70-17	Inc. C17 (813)	8,810	27.46	16.1	8.9	134
4791	2791-HGSaa x A	8,650	26.86	16.1	16.7	104
417(Ore.)	Inc. 713A	8,460	27.22	15.6	12.0	126
417-1	BRS 813	8,450	26.26	16.1	1.0	123
3791	2791aa x A	8,440	25.96	16.3	12.2	137
4791E	2791-LSaa x A	8,260	25.68	16.1	12.5	143
4789	3789aa x A	8,200	23.61	17.4	9.3	130
4791C	2791-LGSaa x A	8,020	25.15	16.0	15.0	140
4790	3790aa x A	8,010	23.64	16.9	4.7	114
Y417H0	Y317H2 x Y317	7,980	25.14	15.9	12.4	124
4791B	YRS 2791	7,440	22.23	16.7	12.9	131
4791D	2791-HSaa x A	7,370	23.55	15.7	18.5	138
E406	ERS E306	7,250	22.96	15.8	48.1	137
Mean		8,580	26.74	16.07	14.5	133
LSD (.05)		858	2.50	0.65	7.1	15.8
CV (%)		11.3	10.6	4.6	55.3	13.4
F value		5.3**	7.8**	3.9**	14.5**	3.6**

** Exceeds the 1% point of significance.

DIPLOID-TRIPLOID TEST, BRAWLEY, CALIFORNIA, 1974-75

10 replications
2 row plots, 40 ft. long

Planted: September 12, 1974
Harvested: May 15, 1975

Variety	Description	Acre Yield		Sucrose	Bolting	Beets/ 100'
		Sugar Pounds	Beets Tons	Percent	Percent	Number
417H29	(718HO x 536-97) x 813 (C17)	8,860	29.52	15.0	13.4	154
417TH29	(718HO x 536-97) x 117T	8,430	29.80	14.1	10.2	146
417H8	546H3 x 813 (C17)	8,810	29.58	14.9	14.1	152
417TH8	546H3 x 117T	8,160	28.38	14.4	11.1	143
417H21	536-97HO x 813 (C17)	8,360	28.26	14.8	9.1	150
417TH21	536-97HO x 117T	8,210	28.65	14.3	8.0	142
417H28	(562HO x 536-97) x 813 (C17)	8,360	28.09	14.9	9.3	158
417TH28	(562HO x 536-97) x 117T	8,250	28.62	14.4	9.0	143
US H10B	Standard check	8,360	27.81	15.0	10.3	160
Mean		8,420	28.75	14.64	10.5	150
LSD (.05)		471	NS	0.45	2.8	8.7
CV (%)		6.3	5.8	3.5	30.0	6.5
F value		2.2*	NS	4.3**	4.2**	4.8**

* Exceeds the 5% point of significance (F = 2.07).
** Exceeds the 1% point of significance (F = 2.77).

VARIETY TEST, IMPERIAL VALLEY, CALIFORNIA, 1975
by Holly Sugar Corporation

9 replications, 1 row plots
25 ft. long, 32 in. between rows

Planted: September 20, 1974
Harvested: June 10, 1975

Variety	Description	Ext. Sugar/A	Ext. Sugar/T	Gross Sugar/A	Beets/A	Sucrose	Bolting	Beets/ 100'
		Pounds	Pounds	Pounds	Tons	Percent	Percent	Number
Y322H80	(564HO x 718) x Y222A	7,277	173.2	10,958	42.1	13.03	20.6	140
Y401H29	(718HO x 536-97) x Y201	7,069	177.1	10,543	39.9	13.21	13.3	137
Y417H31	(562HO x 718) x Y317	6,929	173.8	10,415	39.9	13.06	5.7	140
Y401H31	(562HO x 718) x Y201	6,852	175.2	10,265	39.1	13.12	15.5	137
US H9B	F69-546H3 x C413	6,825	177.5	10,169	38.5	13.21	7.1	139
US H10A	F69-546H3 x C817	6,767	174.7	10,151	38.8	13.09	5.9	144
417H31	(562HO x 718) x 813	6,636	168.5	10,116	39.6	12.82	19.2	141
417H29	(718HO x 536-97) x 813	6,517	164.0	10,038	39.8	12.63	4.7	141
417H82	(705HO x 718) x 813	6,509	169.1	9,905	38.5	12.86	5.7	140
US H10B	F69-569H3 x C817	6,448	177.3	9,627	36.6	13.20	4.6	136
US H9A	F69-569H3 x C413	6,436	163.0	9,944	39.5	12.59	5.8	139
Y418H8	(562HO x 546) x Y318	6,369	165.5	9,776	38.6	12.68	6.8	144
417H28	(562HO x 536-97) x 813	6,350	172.8	9,571	36.8	13.02	8.4	137
464H8	(562HO x 546) x F66-64	5,731	176.2	8,569	32.6	13.17	9.1	136
417H21	3536-97HO x 813	5,602	159.3	8,736	35.2	12.42	5.8	144
Y440H29	(718HO x 536-97) x 3254	5,497	162.9	8,494	33.8	12.57	12.0	144
Test Mean		6,489	170.6	9,830	38.1	12.92	9.4	140
LSD (.05)		540	12.4	646	2.4	0.54	--	--
Coefficient of Variation (%)		9	7.8	7	6.6	4.46	--	--
Standard Error of the Mean		193	4.4	231	0.8	0.19	--	--
F value		6.95**	1.87*	9.22**	8.70**	1.92*	--	--

*Exceeds the 5% point of significance (F = 1.78).
**Exceeds the 1% point of significance (F = 2.25).

VARIETY TEST, TRACY, CALIFORNIA, 1975
By Holly Sugar Corporation

9 replications, 1 row plots
25 ft. long, 30 in. between rows

Planted: June 5, 1975
Harvested: October 29, 1975

Variety	Description	Ext. Sugar/A	Ext. Sugar/T	Gross Sugar/A	Beets/A	Sucrose	Beets/ 100'
		Pounds	Pounds	Pounds	Tons	Percent	Number
Y401H31	(562HO x 718) x Y201	5,751	220.1	7,369	26.2	14.08	83
Y440H8	(562HO x 546) x 3254	5,439	227.5	6,861	23.9	14.36	93
417H27	(718HO x 565) x 813	5,428	202.4	7,193	26.9	13.40	77
US H10B	546H3 x F70-17	5,359	216.2	6,919	24.9	13.94	100
Y442H8	(562HO x 546) x 3256	5,355	221.6	6,823	24.1	14.13	90
Y441H8	(562HO x 546) x 3255	5,155	215.3	6,667	24.1	13.89	95
417H34	(705HO x 546) x 813	5,093	212.4	6,623	24.1	13.78	96
Y401H29	(718HO x 536-97) x Y201	5,015	207.3	6,568	24.1	13.59	90
Y417H31	(562HO x 718) x Y317	5,000	212.7	6,481	23.5	13.79	77
Y401H33	(718HO x 546) x Y201	4,999	209.9	6,532	23.9	13.69	83
417H31	(562HO x 718) x 813	4,962	207.9	6,498	23.9	13.61	90
417H33	(718HO x 546) x 813	4,901	203.3	6,488	24.3	13.41	87
417H29	(718HO x 536-97) x 813	4,880	210.0	6,374	23.3	13.70	89
464H8	(562HO x 546) x F66-64	4,871	214.1	6,310	22.8	13.84	85
417H28	(562HO x 536-97) x 813	4,688	210.7	6,116	22.4	13.71	92
417H21	536-97HO x 813	4,509	196.9	6,064	23.2	13.17	85
Test Mean		5,088	211.8	6,618	24.1	13.76	88
LSD (.05)		492	NS	580	2.4	NS	--
Coefficient of Variation (%)		10	9.1	9	10.5	5.47	--
Standard Error of the Mean		176	6.4	207	0.8	0.25	--
F value		3.20**	1.41	2.89**	1.82*	1.40	--

*Exceeds the 5% point of significance (F = 1.77).
**Exceeds the 1% point of significance (F = 2.22).

Note: Light powdery mildew and yellows. Stands somewhat weak causing deferential competition between plots.

DATA ON USDA VARIETIES TESTED BY SPRECKELS SUGAR COMPANY
1975

Test Areas:

Variety	Description	SPRECKELS Sugar T/Ac.	SPRECKELS Beets T/Ac.	SPRECKELS % Sug.	SPRECKELS % Bolt.	MENDOTA Sugar T/Ac.	MENDOTA Beets T/Ac.	MENDOTA % Sug.
US H9B1	546H4 x C413	2.982	25.49	11.7	25.2	3.45	23.0	15.0
US H10B1	546H4 x C817	3.183	26.09	12.2	11.7	3.20	21.9	14.6
417H21	3536-97H0 x 813	3.339	28.54	11.7	5.9	3.06	21.1	14.5
417H32	3718H4(S) x "	3.708	30.90	12.0	10.7	3.05	21.6	14.1
417H33	3546H72B(S)x "	3.196	28.54	11.2	12.1			
417H27	3565H72 x "	3.719	31.52	11.8	10.0	3.36	23.5	14.3
417H28	3536-97H3 x "	3.365	29.01	11.6	7.2	3.32	22.9	14.5
Y417H31	3718H3 x Y317	3.172	27.58	11.5	12.8	3.18	21.6	14.7
Y401H31	3718H3 x Y201	3.674	30.87	11.9	18.7			
Y401H33	3546H72B x Y201	3.489	29.32	11.9	18.7			
Y440H29	3536-97H72x 3254	3.508	29.65	11.8	8.1	2.91	20.8	14.0
GENERAL MEAN		3.40	28.81	11.8	12.9	3.27	22.4	14.6
LSD @ P = .05		0.375	2.93	NS	2.93	0.42	NS	NS
LSD @ P = .01		0.490	3.83	NS	3.82	NS	NS	NS
S E of Mean		0.136	1.066	0.288	1.065	0.149	1.058	0.251
S E in % of Mean		4.02	3.70	2.44	8.27	4.51	4.72	1.72
No. of Varieties in Test		12	12	12	12	16	16	16
Planting Date			December 18, 1974			March, 1975		
Harvesting Date			September 26, 1975			October, 1975		

DATA ON USDA VARIETIES TESTED BY SPRECKELS SUGAR COMPANY
1975

Test Area:		WOODLAND		
Variety	Description	Sugar T/Ac.	Beets T/Ac.	% Sugar
US H9B1	546H4 x C413	2.97	31.9	9.3
US H10B1	546H4 x C817	2.62	29.4	8.9
417H32	3718H4(S) x 813	1.91	23.9	8.0
417H33	3546H72B(S) x "	2.51	29.5	8.5
417H27	3565H72 x "	2.12	23.8	8.9
Y401H31	3718H3 x Y201	2.75	30.2	9.1
Y401H33	3546H72B x "	3.24	34.1	9.5
Y401H29	3536-97H72 x "	2.69	30.2	8.9
	GENERAL MEAN	2.69	29.6	9.1
	LSD @ P = .05	0.35	3.1	0.7
	= .01	0.44	3.9	0.95
	S E of Mean	0.134	1.175	0.287
	S E in % of Mean	5.01	3.97	3.16
	No. of Var. in Test	16		
	Planting Date	April 22, 1975		
	Harvesting Date	September 22, 1975		
US H9B1	546H4 x C413	5.12	35.2	14.6
US H10B1	" x C817	5.09	34.4	14.8
364H80	2718H5 x F66-64	4.68	32.3	14.5
317H80	2718H5 x C17	4.91	34.6	14.2
317H82	2718H54 x "	5.06	35.9	14.1
Y301H8	F70-546H3 x Y201	4.95	34.4	14.4
Y301H80	2718H5 x "	5.03	34.7	14.5
Y322H8	F70-546H3 x Y222A	4.98	33.9	14.7
	GENERAL MEAN	5.03	34.7	14.5
	LSD @ P = .05	NS	NS	NS
	= .01	NS	NS	NS
	S E of Mean	0.146	0.934	0.166
	S E in % of Mean	2.91	2.69	1.15
	No. of Var. in Test	12		
	Planting Date	May, 1974		
	Harvesting Date	June, 1975		

VARIETY TEST, DIXON, CALIFORNIA, SPRING HARVEST, 1975
American Crystal Hybrids
By American Crystal Sugar Company
424-5

Planted: May 9, 1974
Harvested: March 29-April 7, 1975

Variety	Acre Yield Gross Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Na PPM	K PPM	Amino N PPM	Raffinose Percent	Kestose Percent
71-114	10,185	30.57	16.72	630	1185	326	.029	.004
S-72-400	9,748	28.74	16.98	518	953	361	.053	.010
S-72-381	9,730	28.34	17.20	518	1117	395	.052	.007
S-72-307	9,462	27.72	17.08	391	1018	311	.048	.007
S-72-320	9,345	27.31	17.13	384	1081	333	.047	.008
S-73-1196	8,881	27.31	16.28	524	1179	414	.047	.008
S-72-316	8,584	25.24	17.03	378	1143	308	.050	.010
S-73-1360	8,544	25.64	16.67	523	1131	356	.045	.008
US H10B	8,488	25.63	16.60	378	1228	349	.043	.008
S-73-1319	8,447	24.54	17.22	412	943	436	.049	.004
71-122	8,265	24.95	16.62	390	961	380	.057	.009
S-73-1309	7,840	22.81	17.18	412	959	402	.045	.008
Mean	8,960	26.57	16.89	454	1075	364	.047	.008
LSD (.05)	682	2.09	0.36	77	140	NS	.012	NS
C.V. (%)	6.57	6.80	1.86	15.40	11.30	33.28	22.00	62.50
F value	8.89**	8.46**	5.65**	9.36**	4.35**	NS	2.66**	NS

VARIETY TEST, DIXON, CALIFORNIA, SPRING HARVEST, 1975
USDA Hybrids
By American Crystal Sugar Company
424-6

Planted: May 9, 1974
Harvested: March 29-April 7, 1975

Variety	Description	Acre Yield Gross Sugar Pounds	Beets Tons	Sucrose Percent	Na PPM	K PPM	Amino N PPM	Raffinose Percent	Kestose Percent
317H80	(564H0 x 718) x C17	7,040	21.81	16.14	455	1662	454	.042	.005
Y301H80	(564H0 x 718) x Y201	6,966	21.28	16.35	536	1780	398	.044	.006
364H80	(564H0 x 718) x F66-64	6,808	20.82	16.34	540	1810	446	.037	.004
Y301H8	546H3 x Y201	6,704	20.28	16.52	524	1600	422	.028	.010
317H62	8536H1 x C17	6,537	19.98	16.32	470	1621	430	.029	.004
Y331H8	546H3 x Y231	6,446	19.82	16.24	583	1645	437	.040	.009
317H82	(705H0 x 718) x C17	6,421	19.93	16.12	494	1762	408	.035	.004
US H10B	546H3 x C17	6,390	19.47	16.34	382	1502	329	.037	.009
317H52	522H1 x C17	6,235	18.87	16.50	379	1560	349	.029	.008
Y334H8	546H3 x 234-1,2	5,966	18.04	16.54	446	1585	411	.036	.013
Y204H16	546H5 x Y104	5,538	16.74	16.54	456	1684	377	.035	.007
Y322H8	546H3 x Y222A	4,655	14.44	16.15	503	1717	438	.037	.008
Mean		6,309	19.29	16.34	481	1661	408	.036	.007
LSD (.05)		851	2.47	NS	93	177	74	NS	NS
Coefficient of Variation (%)		11.67	11.08	2.87	16.88	9.24	15.68	43.88	78.14
F value		4.94**	5.56**	NS	3.50**	2.24*	2.23*	NS	NS

VARIETY TEST, CLARKSBURG, CALIFORNIA, FALL HARVEST, 1975
By American Crystal Sugar Company
524-5

8 x 8 Latin square
2 row plots, 25 ft. long, 22 in. rows

Planted: April 10, 1975
Harvested: August 15, 1975

Variety	Description	Acre Yield: Gross Sugar Pounds	Acre Yield: Recov. Sugar Pounds	Beets Tons	Sucrose Percent	Recov. Sugar/ton Pounds	Amino N PPM	Na PPM	K PPM	Impurity Index
Y401H31	(562H0 x 718) x Y201	2,900	2,740	9.5	15.3	289	81	822	786	5609
Y331H8	(562H0 x 546) x Y231	2,760	2,590	9.0	15.4	289	102	906	888	6363
Y301H80	(564H0 x 718) x Y201	2,740	2,580	9.0	15.1	284	99	846	818	5949
Y401H33	(718H0 x 546) x Y201	2,680	2,520	8.9	15.1	283	99	904	848	6225
Y301H8	(562H0 x 546) x Y201	2,670	2,530	8.7	15.3	290	91	792	793	5617
Y401H29	(718H0 x 536-97) x Y201	2,500	2,360	8.2	15.2	286	90	920	725	5882
Y322H80	(564H0 x 718) x Y222A	2,420	2,290	8.0	15.1	284	98	762	842	5698
US H10B	Standard check	2,310	2,190	7.8	14.9	282	81	723	844	5408
Mean		2,620	2,470	8.6	15.2	286	93	834	818	5844
LSD (.05)		NS	NS	NS	NS	NS	NS	110	115	563
Coefficient of Variation (%)		15.2	15.1	15.3	2.5	2.8	23.4	8.3	8.8	6.0
F value		1.9	1.9	1.6	1.5	1.2	1.2	8.9**	3.8**	6.8**

**Exceeds the 1% point of significance (F = 3.1).

VARIETY TEST, CLARKSBURG, CALIFORNIA, FALL HARVEST, 1975
By American Crystal Sugar Company
524-9

8 x 8 Latin square
2 row plots, 25 ft. long, 22 in. rows

Planted: April 11, 1975
Harvested: August 15, 1975

Variety	Description	Acre Yield: Gross Sugar	Acre Yield: Recov. Sugar	Beets	Sucrose	Recov. Sugar/ton	Amino N	Na	K	Impurity Index
		Pounds	Pounds	Tons	Percent	Pounds	PPM	PPM	PPM	
417H33	(718H0 x 546) x 813	2,930	2,760	9.9	14.7	278	100	679	964	5733
417H34	(705H0 x 546) x 813	2,850	2,700	9.5	15.0	284	92	693	839	5395
Y417H31	(562H0 x 718) x Y317	2,680	2,520	9.1	14.7	276	116	717	895	5845
417H27	(718H0 x 565) x 813	2,620	2,480	9.0	14.6	276	97	655	852	5344
US H10B	Standard check	2,530	2,390	8.5	14.8	281	85	667	900	5390
417H29	(718H0 x 536-97) x 813	2,420	2,290	8.4	14.4	272	88	759	806	5509
417H28	(562H0 x 536-97) x 813	2,320	2,190	7.9	14.6	276	95	714	744	5264
417H21	536-97H0 x 813	2,040	1,920	7.0	14.5	273	101	869	656	5634
Mean		2,550	2,410	8.7	14.7	277	97	719	832	5514
LSD (.05)		519	489	1.7	0.4	9	NS	139	108	NS
Coefficient of Variation (%)		12.8	12.7	12.1	1.8	2.0	22.7	12.1	8.1	7.3
F value		6.3**	6.4**	6.0**	4.4**	4.1**	1.5	5.0**	16.6**	2.0

**Exceeds the 1% point of significance (F = 3.1).

INTERSPECIFIC HYBRIDIZATION

VULGARIS-PROCUMBENS HYBRIDS

Helen Savitsky

Selection in diploid nematode resistant populations. A total of 5,246 F_2 diploid plants were tested for nematode resistance in 1975 from which 744 nematode resistant F_2 plants were selected. Some of the selected F_2 plants have already set seeds and their F_3 progenies are being tested for resistance. From 1,940 F_3 plants, 390 F_3 diploid nematode-resistant plants have been selected. The diploid nematode-resistant plants are vigorous and resemble typical normal sugarbeet plants (Fig. 1). Many diploid nematode-resistant plants have been obtained, but the frequency of resistance transmission in these hybrids is still too low. The diploid nematode resistant hybrids are new genotypes that have a segment of a Beta procumbens chromosome in a chromosome of Beta vulgaris. The rate of transmission of nematode resistance depends upon the behavior of the B. procumbens segment in meiosis of the hybrids. A study of the frequency of resistance transmission and the development of lines with a high frequency of transmission is now the major effort.

To study the frequency of resistance transmission, progenies of 54 F_1 nematode-resistant plants were tested for resistance. The rate of resistance transmission among these F_1 plants varied from 7% to 27%. The variation of transmission in F_2 progenies permitted distribution of F_1 hybrids into five groups with high, medium, and low resistance transmission.

There were 7 F_1 plants that transmitted the resistance over 25%; 9 plants transmitted resistance from 20% to 25%; 15 plants transmitted resistance from 15% to 20%; 10 plants transmitted resistance from 10% to 15%; and 15 plants transmitted resistance to only 10% or less of the progeny.

A study of transmission from different genotypes will make it possible to select progenies with higher rates of transmission. It is not known whether the F_2 progenies of F_1 plants that had higher transmission rates will also have higher frequencies of transmission than the F_2 progenies of F_1 plants with a low rate of transmission. A study of the rate of transmission from F_2 to F_3 in different groups will indicate whether the frequency of transmission is maintained in different groups or individual lines and which breeding methods should be applied to increase the frequency of transmission.

Tests for resistance in F_3 progenies showed that F_2 plants derived from F_1 plants with higher transmission rates (20% to 25% and over) transmitted to the F_3 generation an average 20.92% nematode-resistant plants. The rate of transmission to the F_3 varied from 15.02% to 30.90%, whereas the F_2 plants derived from F_1 plants with a low transmission rate (10% and lower) transmitted resistance to only 10.94% of the F_3 plants. The transmission rate in this group of plants varied from 2.63% to 18.87%. Thus, only the nematode-resistant progenies from plants with the higher rates of transmission should be selected for further work. The nematode-resistant plants in progenies derived from plants with low frequencies of transmission should be discarded.

The diploid nematode-resistant plants are not yet stable. F_2 offspring from the same parental F_1 plant showed different transmission rates in the F_3 generation.

Twenty-one diploid nematode-resistant hybrids were exposed to irradiation in the Lawrence Radiation Laboratory at the University of California.

Meiosis in diploid nematode resistant plants. Meiosis in diploid nematode-resistant plants is now being studied to determine the behavior of the B. procumbens segment. All phases of meiosis are completely normal in some PMC's with the B. vulgaris chromosome bearing the B. procumbens segment proceeding to the gametes and these gametes transmitting nematode resistance. In other PMC's different deviations were observed. In these cells the B. procumbens segment is detached at diakinesis from sugarbeet bivalents. One chromosome of the bivalent is shorter because the B. procumbens segment is separated from it and is connected with the chromosome by only a thin chromatine thread (Fig. 2 diakinesis with normal bivalents, Fig. 3 B. vulgaris bivalents with detached procumbens segment). In some cells the chromatine thread breaks and the segment is thrown into the cytoplasm where it disintegrates. Sometimes in the first metaphase the sugarbeet chromosome with attached segment is not included in the equatorial plate, but lies along side it. Such chromosomes may also remain as laggards on the spindle at the first anaphase (Fig. 4). A normal second anaphase is illustrated in Fig. 5. A second anaphase with a dicentric bridge formed by two sugarbeet chromatids of the broken chromosome that lost the B. procumbens segment is shown in Fig. 6.

Cytological investigations indicated that in some PMC's the B. procumbens segment and sometimes the complete B. vulgaris chromosome with this segment included is lost in meiosis. Loss of the B. procumbens segment is apparently caused by incomplete association with the sugarbeet chromosome at the early phases of meiosis. The low rate of transmission of nematode resistance in diploid hybrids is caused by the loss of the B. procumbens segment in some B. vulgaris bivalents. New cross overs are needed to reduce the size of the B. procumbens segment and to facilitate its transmission.

Obtaining diploid nematode-resistant plants from trisomics. In a few nematode-resistant trisomics the B. procumbens chromosome is thrown out from the nuclei in some cells. Such trisomics are chimeras. They may have 18 and 19 chromosomes in different cells of the same root tip. They may also have root tips with only 18 chromosomes, whereas 19 chromosomes occur in the cells of other root tips. Such trisomics may be a source of error when diploid resistant beets are selected. Therefore, the chromosomal makeup of newly selected diploid beets should be verified by chromosome counts in the plants of their progenies. If these plants have 18 chromosomes, the selected plant was a diploid. Sometimes all resistant plants in the progeny of a selected plant supposed to be a diploid had 19 chromosomes. These plants should be discarded from the group of diploid plants. Such a plant was selected last year in the progeny of an irradiated trisomic. The other new diploid nematode-resistant plant selected last year gave a diploid nematode-resistant progeny. This plant originated from crossing over in a trisomic. This was the third diploid nematode-resistant plant that I selected from 14,000 offspring from trisomics.

VULGARIS-COROLLIFLORA HYBRIDS

Helen Savitsky and J. S. McFarlane

Seeds were obtained from 14 B_5 curly top resistant plants selected last year and their B_6 progenies were tested for curly top resistance. Transmission of curly top resistance to the B_6 progenies was very low (2-3%). The experiments were therefore repeated with B_1, B_2, and B_3 hybrids. Plants of these generations were inoculated three times with a highly virulent strain (Logan) of the curly top virus. Thirty B_1 and B_2 new curly top resistant plants were selected after inoculation. Seeds were obtained from 19 B_2 and 25 B_3 plants that had been previously selected.

It is possible that high levels of curly top resistance are controlled by several genes, and a much larger scale of work may be needed.

VULGARIS-PROCUMBENS HYBRIDS

Fig. 1. Diploid nematode resistant hybrids

Meiosis in diploid nematode resistant hybrids

Fig. 2. Diakinesis with normal bivalents

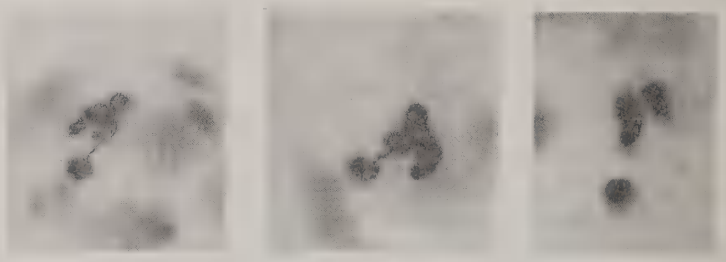

Fig. 3. Bivalents at diakinesis with detached B. procumbens segment

Fig. 4. Chromosome with detached segment lagging on the spindle at first anaphase

Fig. 5. Normal second anaphase

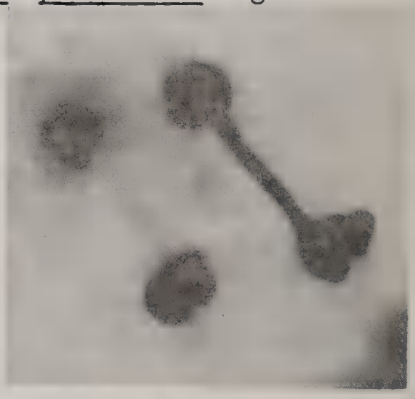

Fig. 6. Dicentric bridge at the second anaphase

Studies of Interspecific Hybridization in *Beta* Species

M. H. Yu

Investigations are concerned primarily with developing lines for resistance to sugarbeet cyst nematode, *Heterodera schachtii*. The material that has been examined included both diploid and trisomic nematode resistant (NR) hybrid progenies. Seedlings were planted individually in aluminum cylinders that contained nematode-infested soil and were also inoculated with cysts within a week after planting. Tests were conducted in the greenhouse under controlled temperature. Examination for the female cysts was done 6 weeks after inoculation. Only those plants with less than 10 cysts on the roots at each check were saved for further study.

In the summer of 1975 hybrid seeds from crosses between diploid NR plants and nematode susceptible (NS) sugarbeets were received from Dr. Helen Savitsky. The 637 available seedlings were screened for NR plants. After 3 inoculations 140 NR hybrids were recovered. The transmission of nematode resistance was approximately 22%. Instead of the diploid chromosome number (18), one NR plant was found to have 20 chromosomes. Unless the female parent had an egg with two extra chromosomes, this showed that an unbalanced pollen grain, i.e., pollen with extra chromosome(s), was functioning in this particular case. Transmission of extra chromosome(s) through pollen of sugarbeet has rarely, if ever, been reported.

Some 40 trisomic *B. vulgaris* x *B. procumbens* NR hybrid plants were transplanted to an isolation plot to promote interpollination by Dr. James C. Read in 1974. Seed from each plant was harvested separately. Out of the 2,500 seedlings thus far tested, 217 NR plants have been identified. Averaged over the 30 progeny groups tested, the rate of nematode-resistance transmission was 8.62% (Table 1). Most of the NR plants were trisomics, except 2 that had 18 chromosomes. Seven nematode susceptible, 19-chromosome sugarbeets were also observed. The occurrence of NR 18 chromosome and NS 19 chromosome plants indicated that crossing over or translocation had occurred between chromosome segments of sugarbeet and *B. procumbens*. Since no tetraploid plants were detected among the 2,500 progenies, the unbalanced pollen grains either failed to take part in fertilization or they competed only with difficulty against normal haploid pollen grains.

In sporocytes of the NR trisomics few trivalents were observed. The extra chromosome, assumed to be transmitted from the original *B. procumbens* parent, usually failed in synapsis and subsequently failed at telophase to be included in either nucleus. Nevertheless, some univalents were incorporated into one of the two nuclei and proceeded normally through meiotic divisions. In this case, both 9-chromosome and 10-chromosome gametes, male or female, resulted. The low percentage of resistance transmission (8.62%, in Table 1) indicated that, in most cases, univalents were excluded during the progress of meiosis.

Somatic chromosome study is important in the process of interspecific hybridization. Chromosome counting on large scale depends upon the development of a technique in which a sufficient spread of individual chromosomes is achieved at certain mitotic stages. For this reason, proper pretreatment of the collected material becomes urgent. The chemicals including colchicine, coumarin, cycloheximide, esculin, 8 hydroxyquinoline, monobromonaphthalene, paradichlorobenzene, phloroglucinol, and cold water are being tested for this purpose.

To enhance the chances of obtaining the desirable crossovers and/or translocations, a number of trisomic NR plants were irradiated with ^{60}Co. Plants were grouped according to the maturity of inflorescences, and irradiated at different dosages. Irradiated plants were pollinated by selected pollinators. Seeds from those crosses have been harvested.

Species within the Patellares section of Beta genus are known to have extremely high resistance, or immunity, to Cercospora leaf spot, curly top, and nematodes, and have monogerm seeds. Some 40 different sources of B. procumbens, B. patellaris, and B. webbiana seeds were obtained from various researchers and institutes. It has been found that not all sources of patellaris and webbiana species are immune to nematodes. Interspecific hybrids will be made between B. vulgaris and these wild species to develop nematode and disease resistant genotypes. The hybrids with desirable characteristics will be backcrossed to sugarbeets in an effort to transfer the valuable germplasm from immune species to sugarbeet.

Grafting is required for survival of interspecific hybrids, because the first generation seedlings will not produce roots of their own. Several B. vulgaris x B. procumbens hybrids are being grafted on sugarbeet stalks. These grafted hybrids and their backcross progenies will be tested for nematode and leaf spot resistance.

Table 1. Nematode resistance in the progenies of trisomic NR sugarbeets

Parent* Plant	Total Plants No.	Res. Plants No.	Sus. Plants No.	Resistance Percent	Notes
2488	77	9	68	11.69	1-18 chr. res.
2560	83	5	78	6.02	
2565	80	10	70	12.50	1-19 chr. sus.
2631	83	4	79	4.82	
2702	83	3	80	3.61	
2706	84	6	78	7.14	
2901	85	3	82	3.53	
2909	81	14	67	17.28	2-19 chr. sus.
3046	84	7	77	8.33	
3089	84	9	75	10.71	
4055	73	8	65	10.96	
4111	82	10	72	12.20	
4136	82	8	74	9.76	
4169	96	14	82	14.58	
4351	80	11	69	13.75	2-19 chr. sus.
4365	83	4	79	4.82	
4370	108	21	87	19.44	2-19 chr. sus.
4378	99	11	88	11.11	
4469	68	10	58	14.70	
4527	83	2	81	2.41	
4562	81	6	75	7.40	
4619	84	9	75	10.71	
4698	83	2	81	2.40	
4753	83	18	65	21.69	
4755	85	2	83	3.53	
4757	85	1	84	1.18	
4948	73	2	71	2.73	
4974	83	1	82	1.20	
5061	80	2	78	2.50	
5122	85	5	80	5.88	1-18 chr. res.
Totals	2,500	217	2,283	8.62	

*From female plant in an open-pollinated isolation plot.

Effect and Interaction of Yellows Viruses and Powdery Mildew on Yield of Sugarbeet

I. O. Skoyen, R. T. Lewellen, F. J. Hills and J. S. McFarlane

Observations in variety x virus yellows tests at Salinas in 1974 indicated that powdery mildew was more severe in yellows infected than in non-infected treatments but that varieties differed in their reactions. The impact of severe powdery mildew on a susceptible variety was reported in Sugarbeet Research-1974 Report, A56-A58. The purposes of 1975 experiments at Salinas and Davis, California, were to determine, in varieties that varied in powdery mildew and yellows resistance, the losses caused by combinations of infections of powdery mildew with Beet Yellows Virus (BYV) or Beet Western Yellows Virus (BWYV) compared with singly infected and noninfected controls. This information would be important for assessing the potential damage that can be caused in varieties that possess different levels of powdery mildew and yellows resistance. Based on this information, decisions could be made on the value of breeding for powdery mildew resistance within lines adapted to California. Also, the information could be important for deciding the use and timing of control measures if combinations of diseases caused greater or lesser damage than that due to independent infections.

The four varieties used varied in powdery mildew and yellows resistance. Their respective disease reactions based on foliar symptoms are listed below:

	Source	Yellows	P. Mildew
3204	Holland	MR[1/]	MR
Maris Vanguard	England	S	MR
417	Inc. C17	MR	S
468	US 75	S	S

[1/] MR = Moderately resistant; S = Susceptible

The Salinas test was seeded May 8, 1975, and the Davis test on May 1, 1975. Each test included three levels of yellows virus, two levels of powdery mildew and the four varieties as sub subplots with five replications at Salinas and six at Davis.

The BYV and BWYV inoculations were made on June 19 at Davis and on June 26 at Salinas. Spraying with wettable sulfur (10 lbs in 50 gal/A) for powdery mildew control was started on July 16 at Davis with repeated applications on August 13 and September 11. At Salinas, mildew control sprays with wettable sulfur (16 lbs in 200 gal/A) were started July 31. Control sprays were repeated at 4-week intervals, on August 26 and September 23. The plots were harvested October 1 and October 23 at Davis and Salinas, respectively.

RESULTS--The means for gross sugar, tons per acre, root yield, and percent sucrose for virus and powdery mildew treatments over all varieties for both locations are shown in Table 1. Check plots showed significance between all varieties for gross sugar at Salinas but not between Maris and 468 at Davis. Variety 3204 was lowest for gross sugar at both locations. Root yields were the same for 417 and 468 at Salinas, but they were significantly lower and higher than Maris and 3204 respectively. At Davis, differences were significant between all varieties. For percent sucrose, 3204, 417, and 468 were no different at either location; Maris had significantly lower sucrose at both Salinas and Davis. Control of powdery mildew with sulfur significantly increased gross sugar yield of the varieties over all yellows virus treatments at Davis and at Salinas except for 3204.

The effect of BYV and BWYV on varieties, the interactions, and the percent losses due to yellows are shown in Table 2. Differences between BYV and BWYV were highly significant at both locations for gross sugar and root yield and for percent sucrose at Davis but not at Salinas. The yellows by variety interaction was highly significant for gross sugar and root yield and significant for percent sucrose at both locations. The results show that for both tests, 417 was damaged the least by BYV; however, 3204 generally showed only slightly higher loss percentages for gross sugar, root yield and sucrose. US 75 (the parent line of 417) had the greatest losses over all yield components.

Both 417 and 3204 showed no damage from BWYV at Salinas. However, at Davis 3204 had significant damage from BWYV. The reaction of Maris to BWYV was intermediate and 468 suffered the most damage at both locations.

The effect of powdery mildew and the interaction with varieties is shown in Table 2. Powdery mildew caused significant yield losses in all varieties at Davis but only in 417, 468, and Maris at Salinas. There was no difference between control and mildew plots of 3204 at Salinas. The interaction, mildew x varieties, was significant only at Salinas, with losses for gross sugar and root yield ranged from 1 to 15% and 1 to 13%, respectively. Both 3204 and Maris had about the same percent loss in the Davis test. Percent sucrose was significantly improved with mildew control only at Davis.

The variable reaction between locations of 3204 to both BYV and BWYV and also to powdery mildew probably reflects its origin and better adaptation to a cool coastal climate such as that at Salinas but not to the warmer more arid climate such as that at Davis.

Interaction between powdery mildew and yellows viruses are shown in Table 3. The interaction was not significant for gross sugar or root yield in the Davis test and not for percent sucrose at either location. At Salinas, mildew control plots yielded higher than mildew plots for all virus treatments. The differences were highly significant for both gross sugar and root yield.

Scores of powdery mildew incidence at different dates and the interaction with varieties are presented in Table 4. The data for the Salinas test show that the increase in powdery mildew at each scoring date was highly significant. The mildew score on the sulfur treated plots was zero. The mildew x variety interaction was also highly significant showing that mildew incidence had increased since the last scoring date but also that the varieties differed in the progressive intensity of mildew. Throughout the period of scoring mildew, 3204 showed the lowest incidence. Comparison of variety scores for the September 20 date at Salinas shows that Maris scored twice as high as 3204, with 417 and 468 three times and 2.5 times as high, respectively. There was no differences for mildew scores between virus treatments. Powdery mildew plots were scored twice at Davis (Table 4). The mean scores showed the same relationships as at Salinas except that 3204 and Maris had identical mildew scores.

Root rot counts were made in the Salinas test at harvest and the analyzed data are shown in Table 5. The BYV treatment had only about 25 percent as much root rot as the other virus treatments and this difference was highly significant. Among varieties, 417 had more than six times as much rot as the next highest variety, 468. The yellows by variety interaction for rot was highly significant and showed BYV inoculated plots of 417 had about 20 percent as much root rot as check and BWYV plots. The reduction in root rot in BYV infected plots has been observed previously. There was no significant rot in 3204 or Maris or difference between virus treatments although the trend was for less rot in the BYV treatment. Apparently 3204, Maris and 468 have a fairly good field grade resistance to Erwinia type root rot.

DISCUSSION--Powdery mildew was less severe in 1975 than in 1974. Yield losses in susceptible lines, as measured by gross sugar, were 15 and 20 percent, respectively at Salinas and Davis, whereas in 1974 losses were nearly 30 percent at both locations. Powdery mildew appeared in the fields slightly later than in 1974 and appeared to develop less rapidly which when combined with the apparent tendency for the disease to recede in severity late in the season, may explain the reduced damage in 1975 compared with 1974.

Disease losses, as measured by gross sugar, that resulted when plots were singly infected with powdery mildew, BYV and BWYV were essentially additive when compared with the losses in plots infected with combinations of mildew and viruses. At Salinas and Davis these percent losses amounted to:

		Salinas		Davis
Combination BYV x PM		34		45
PM + BYV	13 + 29 =	42	16 + 33 =	49
Combination BWYV x PM		20		34
PM + BWYV	13 + 14 =	27	16 + 21 =	37

The tests demonstrate that disease control measures would be warranted in situations where the diseases singly or in combinations might become severe. The test results showed that variety 3204 had resistance to both powdery mildew and the yellows viruses. This suggests that it should be possible to select for or combine mildew resistance in our susceptible lines and retain yellows resistance.

The level of powdery mildew resistance in 3204 was as high as any line evaluated or observed in the breeding program at Salinas. The results of these tests then may give some insight into the potential value of a powdery mildew resistance breeding program and the efficacy of this level of resistance. Under light to moderate powdery mildew infection, as occurred at Salinas, the resistance level of 3204 would be adequate to prevent significant losses without additional control measures. Possibly under more severe exposure to powdery mildew or under different environments as occurred at Davis, this level of resistance would still need to be augmented with chemical control. However, even without chemical control, this level of resistance would appear to retard the development of the infection and to drastically reduce the amount of inoculum produced for secondary infection.

Table 1. Comparative performance at Salinas and Davis of four sugarbeet varieties under combinations of virus yellows and powdery mildew treatments (Salinas Test 2175 and UC Davis).

Yellows Virus Inoculation	Mildew Control	Gross Sugar (lbs/Acre) Salinas Varieties 3204	MARIS	417	468	Means
Check	0	7,648	9,184	7,268	8,062	8,040
	+	8,138	10,052	9,198	9,490	9,220
BYV	0	6,268	6,376	6,064	5,666	6,094
	+	6,046	6,894	6,994	6,180	6,528
BWYV	0	7,736	7,668	7,430	6,806	7,410
	+	7,714	8,500	8,200	7,390	7,950
Means		7,258	8,112	7,526	7,266	7,540

LSD .05 - Varieties = 249

Yellows Virus Inoculation	Mildew Control	Gross Sugar (lbs/Acre) Davis Varieties 3204	MARIS	417	468	Means
Check	0	7,934	8,684	7,834	8,414	8,216
	+	8,930	10,358	9,544	10,262	9,774
BYV	0	5,488	5,670	5,924	4,382	5,366
	+	6,414	6,744	7,348	5,666	6,542
BWYV	0	6,050	6,452	7,298	6,078	6,470
	+	7,180	7,078	9,576	7,000	7,708
Means		7,000	7,498	7,920	6,966	7,346

LSD .05 - Varieties = 375

- -

Yellows Virus Inoculation	Mildew Control	Root Yield (TPA) Salinas Varieties 3204	MARIS	417	468	Means
Check	0	24.8	30.3	23.5	26.3	26.2
	+	26.1	33.2	29.5	30.2	29.8
BYV	0	20.9	22.2	20.1	19.3	20.6
	+	20.5	23.8	22.7	21.0	22.0
BWYV	0	25.4	26.8	24.7	22.8	24.9
	+	25.2	29.8	26.3	24.8	26.5
Means		23.8	27.7	24.5	24.1	25.0

LSD .05 - Varieties = 0.8

Yellows Virus Inoculation	Mildew Control	Root Yield (TPA) Davis Varieties 3204	MARIS	417	468	Means
Check	0	31.4	36.2	29.3	33.1	32.5
	+	33.7	41.1	35.3	38.2	37.1
BYV	0	22.5	24.2	22.9	17.8	21.9
	+	24.9	27.8	27.7	23.1	25.9
BWYV	0	26.0	30.7	29.5	25.5	27.9
	+	29.8	32.9	36.3	28.9	32.0
Means		28.0	32.2	30.2	27.8	29.5

LSD .05 - Varieties = 1.4

Table 1. continued

Yellows Virus Inoculation	Mildew Control	Percent Sucrose Salinas Varieties 3204	Maris	417	468	Means
Check	0	15.5	15.1	15.5	15.3	15.4
	+	15.6	15.1	15.6	15.7	15.5
BYV	0	15.0	14.3	15.1	14.7	14.8
	+	14.7	14.5	15.4	14.8	14.8
BWYV	0	15.2	14.3	15.0	14.9	14.9
	+	15.4	14.3	15.6	14.9	15.0
Means		15.2	14.6	15.4	15.0	15.1

LSD .05 - Varieties = 0.2

Yellows Virus Inoculation	Mildew Control	Percent Sucrose Davis Varieties 3204	Maris	417	468	Means
Check	0	12.6	12.1	13.4	12.7	12.7
	+	13.3	12.6	13.5	13.4	13.2
BYV	0	12.2	11.7	12.9	12.3	12.3
	+	12.8	12.1	13.3	12.3	12.6
BWYV	0	11.7	10.6	12.4	11.9	11.6
	+	12.1	10.8	13.2	12.1	12.0
Means		12.4	11.6	13.1	12.5	12.4

LSD .05 - Varieties = 0.2

Table 2. Interactions of varieties, yellows viruses and powdery mildew at Salinas and Davis (Salinas Test 2175 and UC Davis).

		Gross Sugar (lbs/A)									
		Salinas Varieties					Davis Varieties				
Interaction	Factor	3204	Maris	417	468	Mean	3204	Maris	417	468	Mean
Yellows X Varieties	0	7,894	9,618	8,232	8,776	8,630	8,432	9,522	8,688	9,338	8,996
	BYV	6,156	6,636	6,530	5,928	6,312	5,952	6,206	6,636	5,024	5,954
	BWYV	7,724	8,084	7,816	7,098	7,680	6,616	6,766	8,438	6,540	7,090
	Mean	7,258	8,113	7,529	7,267	7,541	7,000	7,498	7,921	6,967	7,346
	LSD (.05) - Yellows = 479						Y = 466				
	- YXV = 431						YXV = 649				
Yield Loss Due to Virus (%)											
	BYV	22.0	31.0	20.7	32.4	26.5	29.4	34.8	23.6	46.2	33.5
	BWYV	2.2	15.9	5.0	19.1	10.6	21.5	28.9	2.9	30.0	20.8
Mildew X Varieties	No Control	7,218	7,742	6,920	6,844	7,181	6,490	6,936	7,018	6,292	6,684
	Sulfur	7,298	8,482	8,132	7,690	7,900	7,508	8,060	8,824	7,642	8,008
	LSD (.05) - Mildew = 150						M = 241				
	- MXV = 340						MXV = NS				
Yield Loss Due to Powdery Mildew (%)											
	No Control	1.1	8.7	14.9	11.0	8.9	13.6	13.9	20.5	17.7	16.5

Table 2. continued

		Root Yield (TPA)									
		Salinas Varieties					Davis Varieties				
Interaction	Factor	3204	Maris	417	468	Mean	3204	Maris	417	468	Mean
Yellows X Varieties	0	25.4	31.8	26.5	28.3	28.0	32.5	38.6	32.3	35.6	34.8
	BYV	20.7	23.0	21.4	20.1	21.3	23.7	26.0	25.3	20.4	23.8
	BWYV	25.3	28.3	25.5	23.8	25.7	27.9	31.8	32.9	27.2	30.0
	Mean	23.8	27.7	24.5	24.1	25.0	28.0	32.1	30.2	27.7	29.4
	LSD (.05) - Yellows = 1.11						Y = 2.40				
	- YXV = 1.40						YXV = 2.37				
Yield Loss Due to Virus (%)											
	BYV	18.5	27.7	19.2	29.0	23.6	27.2	32.7	21.7	42.6	31.0
	BWYV	0.4	11.0	3.8	15.9	7.8	14.3	17.7	-1.8	23.6	13.4
Mildew X Varieties	No Control	23.7	26.4	22.8	22.8	23.9	26.6	30.4	27.2	25.5	27.4
	Sulfur	23.9	28.9	26.2	25.3	26.1	29.4	33.9	33.1	30.1	31.6
	LSD (.05) - Mildew = 0.55						M = 1.0				
	- MXV = 1.14						MXV = NS				
Yield Loss Due to Powdery Mildew (%)											
	No Control	1.0	8.6	12.9	10.0	8.1	9.6	10.5	17.7	15.3	13.3

Table 2. continued

Interaction	Factor	Percent Sucrose									
		Salinas Varieties					Davis Varieties				
		3204	Maris	417	468	Mean	3204	Maris	417	468	Mean
Yellows X Varieties	0	15.5	15.1	15.5	15.5	15.4	13.0	12.3	13.5	13.1	13.0
	BYV	14.9	14.4	15.2	14.7	14.8	12.5	11.9	13.1	12.3	12.4
	BWYV	15.3	14.3	15.3	14.9	15.0	11.9	10.7	12.8	12.0	11.8
	Mean	15.2	14.6	15.3	15.0	15.1	12.5	11.6	13.1	12.5	12.4
	LSD (.05) - Yellows = NS						Y = 0.33				
	- YXV = 0.32						YXV = 0.34				
Sucrose Loss Due to Virus (%)											
	BYV	4.2	4.9	1.8	5.2		3.7	3.6	2.8	6.3	
	BWYV	1.5	5.6	1.2	3.9		8.4	13.5	5.1	8.2	
Mildew X Varieties	No Control	15.2	14.6	15.2	15.0		12.2	11.4	12.9	12.3	
	Sulfur	15.2	14.6	15.5	15.1		12.8	11.8	13.3	12.6	
	LSD (.05) - Mildew = NS						M = 0.32				
	- MXV = NS						MXV = NS				

Table 3. Interactions of powdery mildew and yellows viruses at Salinas and Davis (Salinas Test 2175 and UC Davis).

Interaction	Virus Treatment	Salinas Mildew Control None	Salinas Mildew Control Sulfur	Salinas Mean	Davis Mildew Control None	Davis Mildew Control Sulfur	Davis Mean
Gross Sugar							
Mildew X	0	8,040	9,220	8,630	8,216	9,774	8,995
Yellows	BYV	6,094	6,532	6,313	5,366	6,542	5,954
	BWYV	7,410	7,950	7,680	6,470	7,708	7,089
	Mean	7,181	7,901	7,541	6,684	8,008	7,346
	LSD (.05) MXY = 260				NS		
Root Yield (TPA)							
Mildew X	0	26.2	29.8	28.0	32.5	37.1	34.8
Yellows	BYV	20.6	22.0	21.3	21.9	25.9	23.9
	BWYV	24.9	26.5	25.7	27.9	32.0	30.0
	Mean	23.9	26.1	25.0	27.4	31.7	29.6
	LSD (.05) MXY = 0.96				NS		
Percent Sucrose							
Mildew X	0	15.4	15.5	15.5	12.7	13.2	13.0
Yellows	BYV	14.8	14.8	14.8	12.3	12.6	12.5
	BWYV	14.9	15.0	15.0	11.6	12.1	11.9
	Mean	15.0	15.1	15.1	12.2	12.6	12.4
	LSD (.05) MXY = NS				NS		

Table 4. Scores of powdery mildew incidence at different dates and the interaction with four sugarbeet varieties (Salinas Test 2175).

		Date Scored							
		Salinas[1]					Davis[2]		
		8/30	9/6	9/14	9/20	Mean	8/27	9/27	Mean
Mildew Control	None	1.67	2.68	3.65	4.53	3.13	2.50	2.53	2.51
	Sulfur	0	0	0	0	0	0	0	0
LSD (.05) =		0.44	0.62	0.54	0.50				
MXV									
No sulfur X Varieties	3204	0.47	0.93	1.47	2.13	1.25	1.67	1.50	1.58
	Maris	1.40	2.80	3.27	4.20	2.92	1.55	1.61	1.58
	417	2.80	3.67	5.40	6.13	4.50	3.89	3.33	3.61
	468	2.00	3.33	4.47	5.67	3.87	2.89	3.67	3.28
Mean		1.67	2.68	3.65	4.53	3.13	2.50	2.53	2.51
Sulfur X Varieties	3204	0.0	0.0	0.0	0.0				
	Maris	0.0	0.0	0.0	0.0				
	417	0.0	0.0	0.0	0.0				
	468	0.0	0.0	0.0	0.0				
LSD (.05) = V		0.36	0.37	0.23	0.26				
LSD (.05) = MXV		0.50	0.52	0.33	0.37				

1/ Scored on basis of 0-9.

2/ Mildew scores for the Davis test not statistically analyzed. Scored on basis of 0-4.

Table 5. Incidence of Erwinia type root rot in four sugarbeet varieties and the interaction of yellows virus infection with the occurrence of root rot. (Salinas Test 2175)

	ROOT ROT COUNT Varieties				
Treatment	3204	Maris	417	468	Mean
O	0.30	0.70	8.00	1.70	2.68
BYV	0.20	0.60	1.80	0.40	0.75
BWYV	0.50	0.90	8.90	0.80	2.78
Mean	0.33	0.73	6.23	0.97	2.07

LSD (.05) Viruses = 0.80
Varieties = 0.94
Y x V = 1.62

EVALUATION OF BEET MOSAIC VIRUS RESISTANT-SUSCEPTIBLE LINES AND HYBRIDS

R. T. Lewellen and I. O. Skoyen

Tests 2275 and 2375 are continuations of the study on the effects of BMV, BYV, and BWYV on near-isogenic lines that are differentiated by the presence or absence of the Bm allele. (See test 1874, pages A13-A15, A35-A36, Sugarbeet Research, 1974 Report.)

The materials and methods used for Test 2275 were nearly identical to those used in 1974 for Test 1874. For Tests 2275 and 2375, BMV was collected from commercial beet fields growing in the Gilroy-Hollister area of California and was probably less severe than the Byron source used in 1974. Because of problems with rearing aphids on the BWYV sources, a combination of BYV- BWYV was substituted for the BWYV treatment. For Test 2275, nine sets of near-isogenic lines were tested. All sets included F_4B_3 lines homozygous for BmBm or bmbm and six of the sets also included the recurrent parent.

Within each set of lines, agronomic characteristics were very similar. The BMV, BYV, and BYV-BWYV inoculations appeared to cause about 100% infection. Plants mechanically inoculated with BMV developed typical symptoms if they were bmbm but were symptomless if BmBm. (In the greenhouse, BmBm plants inoculated with BMV develop very mild symptoms and are known to be highly resistant rather than immune.) A general spread of all three viruses occurred after mid-August and differences between virus treatments had essentially disappeared by harvest. Powdery mildew infection became quite severe in late August and the trial was subsequently sprayed with wettable sulfur.

The most important observations from tests 2275 and 2375 are:

(1) In susceptible lines (bmbm and the recurrent parents), BMV caused losses in gross sugar yield that varied from 3.8 to 24.3% with an average loss of about 9%. In the same test, BYV caused an average loss of about 18% and BYV-BWYV an average loss of about 25%. These measured losses would probably be even greater if virus infection could be avoided in the noninoculated checks.

(2) The losses in performance associated with BMV infection can essentially be eliminated by the incorporation of the Bm allele.

(3) As also suggested in the 1974 test, the BmBm line from each isogenic set is generally slightly lower in sucrose concentration and slightly more susceptible to yellows, particularly when infected with BWYV. This again suggests a possible linkage or pleiotropic association between the loci for the Bm gene and for factors that affect sucrose concentration and yellows resistance.

(4) The performance data of Test 2275 showed an unusual interaction between lines with the BmBm constitution and BMV infection. This was unexpected and as yet unexplained. Overall and in 8 out of 9 comparisons for gross sugar yield (9 out of 9 for beet yield), a higher yield occurred when the BmBm line was inoculated with BMV than when left as a non-inoculated check. In fact, the highest yielding combination of treatments occurred for the BmBm lines inoculated with BMV.

(5) Because of the apparent association between the Bm locus and factors for sucrose concentration and yellows resistance, an uncertainty remains about the commercial utility of the BMV resistant lines. Also, because Bm does not appear to be completely dominant, the amount of protection provided by this gene when heterozygous hybrids are grown is not known. Test 2375 was grown to try to answer these questions. Although not a highly reliable test, it does suggest that in hybrid combinations Bmbm conditions appreciable resistance to BMV and that sucrose concentration and yellows resistance are not affected.

Footnotes for Test 2275

Significant (P = .01) line x virus treatment interactions occurred for sugar yield, beet yield, % sucrose, root rot, and powdery mildew scores. Significant (P = .01) isogenic type x virus interactions occurred for sugar yield, beet yield, and % sucrose.

1/ Recurrent parents and nearly equivalent BMV resistant (BmBm) and BMV susceptible (bmbm) lines selected from the F_2B_3 and F3B3.

2/ LSD (.05) values for the line x virus treatment interaction means are 469 lb/A, 1.57 T/A, and 0.42% for sugar yield, beet yield, and % sucrose, respectively.

3/ Virus treatment means with a letter in common are not significantly different at the 5% level. LSD (.05) values for isogenic types for different virus treatments are 200 lb/A, 0.53 T/A, and 0.24% for sugar yield, beet yield, and % sucrose, respectively.

4/ LSD (.05) values for isogenic types for different virus treatments are 227 lb/A, 0.70 T/A, and 0.17%.

TEST 2275. EVALUATION OF BEET MOSAIC VIRUS RESISTANT-SUSCEPTIBLE NEAR-ISOGENIC LINES, SALINAS, CALIFORNIA, 1975

10 replications
4 virus treatments
1-row plots, 25 ft. long

Planted: May 7, 1975
Inoculated: BMV on 6/27/75; BYV and BYV-BWYV on 7/9/75
Harvested: October 14-22, 1975

Line[1]	Sugar Yield (lb/A)				Sugar Yield Loss (%)		
	Check	BMV	BYV	BY-BWYV	BMV	BYV	BY-BWYV
C01[2]	8,635	7,827	7,194	6,586	9.3	16.7	23.7
F_4B_3BmBm	8,444	8,650	6,944	6,120	-2.4	17.8	27.5
F_4B_3bmbm	9,414	8,482	7,011	6,586	9.9	25.5	30.0
C04	7,808	7,110	6,428	6,354	8.9	17.7	18.6
F_4B_3BmBm	7,388	7,582	5,918	5,347	-2.6	19.9	27.6
F_4B_3bmbm	7,641	6,900	5,780	5,608	9.7	24.4	26.6
C17	6,815	6,199	5,445	5,099	9.0	20.1	25.2
F_4B_3BmBm	6,865	7,235	5,326	4,834	-5.1	22.4	29.6
F_4B_3bmbm	6,888	6,177	5,747	5,069	10.3	16.6	26.4
C10	8,660	7,477	7,250	6,659	13.7	16.3	23.1
F_4B_3BmBm	7,833	8,108	6,491	5,451	-3.4	17.1	30.4
F_4B_3bmbm	8,129	7,788	6,941	6,302	4.2	14.6	22.5
C21	7,195	6,879	5,857	5,107	4.4	18.6	29.0
F_4B_3BmBm	6,955	7,271	5,246	4,485	-4.3	24.6	35.5
F_4B_3bmbm	6,719	5,647	4,844	4,522	16.0	27.9	32.7
C44	7,260	6,567	6,551	6,020	9.5	9.8	17.1
F_4B_3BmBm	7,860	8,055	6,238	6,126	-2.4	20.6	22.1
F_4B_3bmbm	7,874	7,573	6,959	6,149	3.8	11.6	21.9
60 BmBm	5,095	5,757	3,899	3,677	-11.5	23.5	27.8
60 bmbm	4,465	3,736	3,051	2,933	16.3	31.7	34.3
61 BmBm	5,630	5,842	4,393	3,579	-3.6	22.0	36.4
61 bmbm	5,607	4,798	4,142	3,688	14.4	26.1	34.2
9101BmBm	6,575	6,445	4,681	3,873	2.0	28.8	41.1
9101bmbm	5,802	4,392	3,877	3,855	24.3	33.2	33.6
Mean	7,148a	6,771b	5,675c	5,168d	5.3	20.6	27.7
ISOGENIC TYPE[3]							
Parent	7,724a	6,999b	6,449a	5,959a	9.4	16.5	22.9
BmBm	7,577a	7,829a	6,030b	5,404c	-3.2	20.4	28.7
bmbm	7,780a	7,084b	6,204b	5,704b	8.9	20.3	26.7
ISOGENIC TYPE[4]							
BmBm	6,999a	7,240a	5,459a	4,835a	-3.3	22.0	30.9
bmbm	6,950a	6,143b	5,337a	4,946a	11.6	23.2	28.8

TEST 2275. EVALUATION OF BEET MOSAIC VIRUS RESISTANT-SUSCEPTIBLE NEAR-ISOGENIC LINES, SALINAS, CALIFORNIA, 1975

Line[1]	% Sucrose				Beet Yield (tons/A)	
	Check	BMV	BYV	BY-BWYV	Check	BMV
C01[2]	15.20	15.01	15.16	14.55	28.40	26.06
F_4B_3BmBm	14.25	14.39	13.78	13.11	29.62	30.04
F_4B_3bmbm	14.80	14.86	14.40	13.79	31.87	28.60
C04	14.52	14.56	13.99	13.96	26.93	24.42
F_4B_3BmBm	13.38	13.26	12.85	12.49	27.65	28.60
F_4B_3bmbm	13.92	13.69	13.53	13.28	27.44	25.24
C17	14.92	14.44	14.48	14.11	22.84	21.46
F_4B_3BmBm	14.32	14.22	13.73	13.33	23.97	25.46
F_4B_3bmbm	13.97	14.09	13.97	13.57	24.69	21.89
C10	15.29	14.90	14.93	14.89	28.32	25.05
F_4B_3BmBm	14.89	14.77	14.56	13.79	26.23	27.49
F_4B_3bmbm	15.23	14.98	14.84	14.49	26.72	26.03
C21	14.32	14.21	13.54	13.21	25.12	24.19
F_4B_3BmBm	14.00	14.09	13.16	12.33	24.82	25.75
F_4B_3bmbm	13.98	13.66	13.36	12.82	24.03	20.67
C44	13.95	13.83	13.89	13.55	25.96	23.73
F_4B_3BmBm	13.26	13.08	12.77	12.70	29.49	30.78
F_4B_3bmbm	14.06	13.72	13.45	13.68	27.99	27.59
60 BmBm	15.23	15.51	14.10	14.03	16.76	18.55
60 bmbm	14.90	14.38	13.63	13.62	14.97	12.95
61 BmBm	13.99	13.43	13.15	12.26	20.14	21.76
61 bmbm	14.01	13.59	12.99	12.46	20.02	17.65
9101BmBm	13.22	12.87	11.77	11.33	24.85	25.02
9101bmbm	13.36	12.48	11.96	12.15	21.66	17.53
Mean	14.29a	14.08b	13.67c	13.31d	25.02a	24.02b
ISOGENIC TYPE[3]						
Parent	14.70a	14.49a	14.33a	14.05a	26.27b	24.13c
BmBm	14.02c	13.97c	13.48c	12.96c	26.98a	28.01a
bmbm	14.33b	14.17b	13.93b	13.61b	27.15a	25.01b
ISOGENIC TYPE[4]						
BmBm	14.06a	13.96a	13.32a	12.82a	24.85a	25.93a
bmbm	14.25a	13.94a	13.57a	13.32b	24.38a	22.03b

TEST 2375. EVALUATION OF HYBRIDS WITH BMV RESISTANT POLLINATORS, SALINAS, CALIFORNIA, 1975

5 replications
3 virus treatments
1-row plots, 25 ft. long

Planted: May 7, 1975
Inoculated: BMV on 6/27/75; BY-BWYV on 7/9/75.
Harvested: October 16-17, 1975

Hybrid	Description[1/]	Sugar Yield (lb/A) Check	BMV	BY-BWYV	Sugar Yield Loss (%) BMV	BY-BWYV
US H10B	546H3 x F70-17 (1068)	8,022	7,126	4,962	11.2	38.1
4253H8	546H3 x F_3B_3 C17 bmbm	8,330	6,883	5,580	17.4	33.0
Y402H8	546H3 x F_2B_3 C17 Bm:bm	8,432	7,366	5,695	12.6	32.5
4717H8	546H3 x F_3B_3 C17 BmBm	8,252	7,752	5,844	6.1	29.2
417H31	718H3 x C17	8,297	7,524	6,295	9.3	24.1
Y402H31	718H3 x F_2B_3 C17 Bm:bm	8,747	7,377	6,046	15.7	30.9
4717H31	718H3 x F_3B_3 C17 BmBm	8,336	8,047	5,930	3.5	28.9
4258H8	546H3 x F_3B_3 C21 BmBm	8,282	7,479	5,169	9.7	37.6
Mean		8,338a	7,444b	5,690c	10.7	31.8
LSD (.05)		NS	NS	NS	--	--

Hybrid	Beet Yield (T/A) Check	BMV	% Sucrose Check	BMV	BYV-BWYV
US H10B	27.43	24.77	14.63	14.36	13.64
4253H8	27.73	23.98	15.01	14.36	13.96
Y402H8	29.13	26.26	14.46	14.04	13.64
4717H8	27.82	26.11	14.82	14.84	13.94
417H31	29.06	26.97	14.27	13.96	13.66
Y402H31	30.79	27.11	14.20	13.62	13.36
4717H31	28.85	28.38	14.44	14.18	13.84
4258H8	28.21	26.68	14.67	14.04	13.04
Mean	28.63a	26.28b	14.56a	14.18b	13.64c
LSD (.05)	NS	NS	NS	0.62	NS

[1/] Frequency of Bm and bm alleles in pollinators: bmbm = 100% bm; Bm:bm = 50% Bm, 50% bm; BmBm = 100% Bm.

CORRELATION OF PERFORMANCE AND AGRONOMIC TRAITS IN SPACE-PLANTED, YELLOWS-INFECTED SUGARBEET

R. T. Lewellen, I. O. Skoyen, J. S. McFarlane

At Salinas, mass selections for yellows resistance have been made from space-planted, yellows-infected (BYV-BWYV) plants. It would be of interest in the yellows resistance breeding program to know the relationships and associations of traits in sugarbeet grown under these conditions and with their progeny grown under normal stands, with and without yellows infection. After evaluation of the individual space-planted roots, the present experiment was discontinued because most plants died in the subsequent isolation plots before seed could be set. However, the relationships within three breeding lines are summarized in the following tables.

For each breeding line, 96 roots were selected at random from approximately 600 space-planted, yellows-infected beets. The plots were planted April 26, 1973, on 28" beds and were thinned to 28" stands, inoculated with BYV-BWYV on June 28, and harvested on November 7. After being lifted, the leaves were trimmed to the crown and the roots washed, weighed and scored for crown and root shape. The shape of the crown and root and sprangling were scored as follows:

Crown: 1 = single; 2 = split or double; 3 = multiple
Root shape: 1 = globular; 2 = normal; 3 = elongated
Sprangling: 1 = single; 2 = double; 3 = fangy

The concentrations of sucrose, amino nitrogen, sodium, and potassium for individual roots were determined from brei obtained with a Keil rasp.

The correlation values vary somewhat from breeding line to line possibly reflecting differences in their degree of yellows resistance, genetic background, and the environment. For example, no consistent pattern was evident between root weight and the concentrations (ppm) of the components of impurity. Also, no consistent pattern was evident for relationships between the shape and size of the crown and root. Within all three lines, there were negative relationships between sucrose percentage and the concentration of NH_2-N, Na, and K. The slight positive correlation between root weight and % sucrose might reflect differences for yellows resistance within Y238. That is, in general the more yellows resistant segregates produced both a higher root weight and % sucrose, whereas the more yellows susceptible segregates produced both a lower root weight and % sucrose. The more yellows susceptible line 2775 had a positive but nonsignificant correlation between root weight and % sucrose, whereas the quite yellows susceptible line 2791 had a slight negative correlation.

Correlation of traits in space-planted, yellows infected sugarbeet

	Root Weight	% S	Gross Sugar	N	Na	K	Shape Crown	Shape Root	Sprang.
				Y238					
Root Wt	---	.22*	.97**	-.13	.03	.30**	.35**	-.09	-.05
% S		---	.43**	-.25*	-.57**	-.44**	.22*	.13	.07
Gross S			---	-.18*	-.09	.17*	.37**	-.05	-.03
N				---	-.08	.06	-.10	.02	.14
Na					---	.19*	-.09	-.01	-.17
K						---	-.08	-.25**	-.01
Crown							---	-.06	.03
Shape								---	-.03
Mean	1456 g	13.7%	201 g	990	511	2680	2.1	1.9	2.1
				2775					
Root Wt	---	.15	.97**	.06	-.11	.08	.36**	-.17*	.03
% S		---	.37**	-.12	-.65**	-.44**	.20*	-.24**	.21*
Gross S			---	.02	-.25**	-.04	.39**	-.20*	.07
N				---	-.01	.02	.04	-.11	-.02
Na					---	.14	-.08	.10	-.08
K						---	-.19*	.06	-.18*
Crown							---	-.27**	.26**
Shape								---	-.42**
Mean	1270 g	13.8%	177 g	1691	509	2346	1.8	2.1	1.7
				2791					
Root Wt	---	-.05	.98**	.20*	.25**	.33**	.23*	-.17	-.14
% S		---	.12	-.19*	-.61**	-.55**	-.12	.02	-.10
Gross S			---	.17	.14	.24**	.22*	-.17*	-.15
N				---	.13	.09	.26**	-.27**	-.08
Na					---	.47**	.15	-.11	.01
K						---	.17	-.12	-.02
Crown							---	-.19*	-.11
Shape								---	-.19*
Mean	1148 g	14.7%	168 g	1547	293	2486	1.5	2.1	1.6

Y238 = The F_2 of an open-pollinated line between yellows resistant C17 and yellows susceptible SP 6822-0(B).

2775 = S_1 plants from an open-pollinated composite.

2791 = Open-pollinated progeny from a self-fertile composite.

SUMMARY OF PERFORMANCE EVALUATION OF LINES SELECTED FROM C413 FOR RESISTANCE TO ERWINIA ROT

R. T. Lewellen and E. D. Whitney

The line C413, the pollinator of US H9, was selected twice in combined field and greenhouse selections for resistance to Erwinia rot. The several sister selections from C413 were evaluated for performance, yellows resistance, and bolting in tests at Salinas in 1975. In addition, some of these lines were crossed with 546H3, the female parent of US H9B and US H10B, to make hybrids that should be nearly equivalent to US H9B. These hybrids were also evaluated at Salinas in 1975. The results of these trials are summarized below.

Bolting Evaluation Test, Salinas, CA, 1975
Planted: November 22, 1974
Harvested: September 10, 1975

Pollinators[1]	Acre Yield[2] Sugar	Beets	Sucrose	Bolting	Erwinia[3] Rot
	Pounds	Tons	%	%	%
C17	12,270	40.76	15.1 bc	18.1 ab	4.4
C413	12,180	40.44	15.0 bc	35.2 c	4.2
E402	10,690	36.36	14.7 c	28.7 bc	1.5
E406	11,440	37.26	15.4 ab	34.6 c	1.3
E434	11,970	39.82	15.0 bc	25.6 abc	2.1
E435	12,490	40.17	15.6 a	16.7 a	0.5
lsd (.05)	NS	NS	0.4	10.4	3.5
Hybrids					
US H10B	13,500 ab	44.11 ab	15.3	22.7	1.5
E402H8	14,390 a	46.68 a	15.4	23.5	2.8
E406H8	11,870 c	39.75 b	14.9	24.3	0.9
E434H8	12,460 bc	41.34 b	15.1	27.2	0.0
lsd (.05)	1,260	4.19	NS	NS	NS

Hybrid Evaluation Test, Salinas, CA, 1975
Planted: December 18, 1974
Harvested: September 29, 1975

US H10B	12,860	40.88	15.7	23.3	3.6
E402,6H8[4]	12,630	41.13	15.3	19.3	1.2
	NS	NS	NS	NS	**

Virus Yellows Evaluation Tests, Salinas, CA, 1975
Planted: December 19, 1974
Inoculated with BYV-BWYV: May 22, 1975
Harvested: September 22, 1975

Pollinators[1]	Sugar Yield (lb/A)			Beet Yield (T/A)		% Sucrose		Bolt.	Erwinia[3] Rot
	Check	Inoc.	% Loss	Check	Inoc.	Check	Inoc.	%	%
C17	9,270	7,920	14.6	31.75	28.39	14.7	14.0	7.4	5.3
C413	9,390	6,900	26.1	32.78	26.78	14.3	12.9	21.3	2.4
E402	8,950	7,020	21.1	30.65	25.68	14.6	13.7	23.3	0.2
E406	9,820	7,430	24.0	31.75	26.85	15.5	13.9	13.4	0.0
E434	10,480	7,690	25.9	34.63	27.57	15.1	13.9	7.6	0.6
E435	9,880	7,870	19.5	32.81	28.39	15.0	13.9	13.8	0.2
lsd (.05)	925	930	NS	2.82	2.77	0.8	NS	4.9	1.7
Hybrids									
US H10B	11,860	8,990	23.9	38.19	31.30	15.5	14.4	18.4	1.7
E402H8	13,080	8,920	31.6	41.45	31.54	15.8	14.2	12.8	0.9
E406H8	10,860	8,120	25.1	35.14	29.62	15.5	13.7	27.9	0.5
E434H8	11,850	8,860	25.0	37.78	30.75	15.7	14.4	15.8	0.4
lsd (.05)	895	NS	NS	1.92	NS	NS	NS	2.5	NS

1/ C17 is the pollinator of US H10 and was derived from C413.
C413 is the pollinator of US H9.
E-- numbers are selections for Erwinia rot resistance from C413.
E---H8 are hybrids using the Erwinia resistant selections and should be nearly equivalent to US H9B.
US H10B was used as a check.

2/ Means with a letter in common are not significantly different at the 5% level.

3/ These values are the percentage of roots at harvest that showed Erwinia rot. This infection was due to natural infection.

4/ Blend of E402H8 and E406H8.

From a commercial standpoint, the most important comparisons are between the hybrids. With one year's data from one location, conclusions can be somewhat hazardous. In general, however, it appears that for most traits, the hybrids with Erwinia resistant pollinators are essentially equal to US H10B. Testing of the most promising hybrids will be continued in 1976.

Resistance of selected lines to Erwinia root rot under severe exposure

E. D. Whitney and R. T. Lewellen

Lines and related selections, most of which were selected from C413 were evaluated at two locations (Spence and Salinas, California) in 1975 under potentially severe root rot conditions. The selections were planted in a randomized block design on May 5 at Salinas and June 4 at Spence and the beets harvested September 29 and October 6, respectively. All harvestable beets from each plot were used to estimate each variable. To maximize the possibility of infection and subsequent rot all plants were injured and then immediately inoculated with a suspension of Erwinia. Inoculations were made when the plants were about 10 weeks old by applying about 1 ml of 10^6 cells per ml of bacterial suspension to each foot of row. The inoculum was applied with a pressurized sprayer. The lines tested are found in Tables 1 and 2.

The results of these tests for gross sugar, beet yield, % sucrose, % rot per beet and % of plants infected are shown in Tables 1 and 2. The selected lines E402, E406 and E434 and hybrids with 546H3 from these selections, E402 H8, E406 H8, and E434 H8, were in most cases superior to the parent C413 and the comparable hybrid US H9B, respectively.

The conditions under which these selections and varieties were tested are much more severe than would be expected in the field. The results demonstrate that progress has been made in reducing losses by selecting for resistance to the Erwinia sp. inciting root rot of beet.

Table 1. Performance of Erwinia root rot selection in 1975.

SALINAS PLOT

	Gross Sugar	Beet Yield	% Sugar	% Rot/beet	% Infection
E406H8	5839.8 a	19.88 a	14.76 a	15.5 ab	37.4 ab
E434H8	5620.3 a	18.94 ab	14.81 a	15.4 ab	40.0 ab
US H7A	5588.9 a	19.79 a	14.08 ab	27.9 c	53.3 c
E434	5433.1 ab	19.26 ab	13.94 ab	14.1 ab	35.3 a
E406	5397.5 ab	18.56 abc	14.49 a	12.0 a	44.1 abc
E402H8	5213.3 ab	18.97 ab	13.66 ab	22.9 bc	57.1 cd
F70-546H3	4509.0 bc	15.38 d	14.61 a	22.6 bc	46.6 abc
US H10B	4014.8 c	15.32 d	13.04 bc	42.3 d	66.4 de
E402	3939.5 c	16.11 bcd	12.09 c	18.8 ab	50.2 bc
US H9B	3896.4 c	15.64 cd	12.34 c	44.3 d	70.0 e
C813 (C17)	1592.5 d	7.06 e	10.81 d	73.7 e	82.8 f
C413	1199.3 d	6.66 e	8.48 e	74.5 e	86.7 f

Table 2. Performance of Erwinia root rot selection in 1975.

SPENCE PLOT

	Gross Sugar	Beet Yield	% Sugar	% Rot/beet	% Infection
US H7A	3729.3 a	15.0 a	12.52 a	22.8 a	53.2 a
E402H8	2571.3 b	12.3 b	10.44 bc	32.7 b	75.7 b
E434H8	2507.6 b	11.4 b	10.90 b	26.1 ab	71.9 b
E406H8	2465.2 b	11.4 b	10.82 b	32.2 ab	72.6 b
F70-546H3	2367.9 bc	9.8 c	12.14 a	26.0 ab	60.1 a
E434	1990.5 cd	9.5 c	10.34 bc	31.6 ab	75.1 b
E406	1915.4 d	9.0 c	10.66 b	31.3 ab	81.5 bc
US H10B	1840.1 d	9.5 c	9.75 bc	50.8 c	80.6 bc
US H9B	1632.4 d	8.4 c	9.35 c	53.6 c	82.7 bc
E402	733.9 e	4.5 d	7.79 d	62.4 d	88.9 cd
C413	409.9 e	2.6 e	7.55 d	83.5 e	95.7 d
C813 (C17)	381.4 e	2.8 e	6.73 d	82.2 e	97.1 d

Inheritance of resistance to Erwinia root rot

R. T. Lewellen and E. D. Whitney

Two open-pollinated sugarbeet lines differing in reaction to Erwinia and their segregating progeny were evaluated at Salinas and Spence in 1975. The more susceptible line C17 is the pollinator of US H10 hybrids whereas the more resistant line C64 was the pollinator of US H7 hybrids. Both of these open-pollinated lines show the full range of reactions to Erwinia.

Seed of F_1 and the two backcrosses was obtained under bags in the greenhouse from randomly paired plants. More than 25 pairs of plants were used for each cross. F_2 seed was obtained from a field isolation of F_1 plants. The parental lines and their progeny were grown in replicated field tests. At Salinas each entry was replicated six times and plots were single rows 20 feet long. At Spence there were 10 replications with single-row plots 53 feet long. The F_2 was included three times in each replication in both tests. The plants were thinned to 6 to 8 inch stands.

At about 2 months of age the plants were injured and inoculated with a suspension of Erwinia bacteria. A mixture of isolates was used. The plants were injured by thrusting a disc downward onto the crown of the plant, thus causing numerous wounds in the leaf blades and petioles and partially breaking some petioles away from the crown. The crown and

root of some plants were also injured by this procedure. The Salinas test was examined at 2-week intervals and dead plants were counted and removed. On September 26 and October 6, the Salinas and Spence tests, respectively, were lifted and each root was scored for disease reaction. A scale of 0, VN, 7, 25, 50, 75, 93, and (dead) 100% rot/root was used. The 0% and VN (vascular necrosis in the crown without soft rot) ratings were placed together as a resistant class. The 7 to 100% rot ratings were considered to be varying degrees of susceptibility.

The results of these tests are summarized in the table. The distribution of the resistant and susceptible plants from the parental lines and their progeny were tested against several genetic models but none fit all of the populations. It appears, however, that resistance is primarily due to one major gene with a background of modifiers and quantitative factors. For example, if resistance is assumed to be due to a single, fully penetrant, completely dominant factor, and that dominance conditions the 0% and VN reactions, then the frequencies of the resistant (dominant) allele for C17 and C64 can be calculated from the Salinas data to be about 0.08 and 0.42, respectively. With these parental frequencies, there is a good fit between the observed and expected distributions of the F_1, BCP_1, and BCP_2, but not for the F_2. Using slightly different allele frequencies for the Spence test, there is also a good fit between the observed and expected segregation within the F_1, BCP_1, and BCP_2, but not for the F_2. In both tests, the number of susceptible plants and the % rot/root in the F_2 is regressed toward the susceptible parent.

In addition to the effects due to one major gene, environmental effects and experimental procedures appear to be important factors in the expression of disease reaction.

Frequency of resistant plants and % rot/root for C17 and C64 and their progeny

Generation	Number of plants		% rot/root		% resistant roots (0-VN)	
	Salinas	Spence	Salinas	Spence	Salinas	Spence
P_1 (C17)	206	681	73.0	72.3	14.5	7.0
BCP_1	213	641	47.7	47.2	31.0	17.0
F_2	621	1983	41.6	39.0	34.0	27.9
F_1	224	705	27.9	30.7	46.9	32.9
BCP_2	212	666	20.1	22.6	55.7	43.7
P_2(C64)	203	668	15.7	21.1	66.0	50.6

PRELIMINARY INVESTIGATIONS INTO THE INHERITANCE OF BOLTING RESISTANCE

R. T. Lewellen and I. O. Skoyen

One of the requirements for sugarbeets grown in California and Arizona is a high degree of bolting resistance. The purposes of this preliminary investigation were to obtain information on the expression of the nonbolting tendency under different environments and to determine under what set of environmental and cultural treatments the inheritance of the nonbolting tendency could best be investigated.

The commercial pollinators C17 and SP 6322-0 were used as the bolting resistant and bolting susceptible parents. Though both of these lines are open pollinated, they are fairly closely bred and should be nearly homozygous for factors influencing bolting tendency. Because the seed production environment apparently influences the subsequent bolting tendency of a line, the parents and their progeny were increased in as nearly uniform conditions as possible. C17, SP 6322-0, and their F_2 were increased in adjacent greenhouse isolators. Simultaneously, the F_1, BCP_1, and BCP_2 were produced in the greenhouse from paired plants under paper bags. The parental lines and their progeny were planted and rated for bolting at Phoenix, Salinas, and Salem. In addition 417-1, a selection made for bolting resistance from C17 and increased in an isolator adjacent to C17, was evaluated.

The results are summarized in the tables. Because of the problems with incomplete bolting, especially within the more bolting resistant lines, the data from Phoenix and Salinas may not easily lend themselves to genetic analysis. However, with modifications, the inheritance of bolting resistance could probably be determined at Salem. The counts of the bolters at Salem were nearly normally distributed for all populations and distinct differences in the mean date of bolting occurred between the parents. The interval between counting dates should probably be decreased in future tests. Even though the rate of bolting was much more compact and complete at Salem, the relationship between the parents and lines was fairly consistent across all locations and counting dates. The findings at any one location, then, should be predictive of what the bolting tendency of these lines would be at any other location.

At all three locations, the segregating populations were regressed toward the more bolting susceptible parent, suggesting that bolting resistance is inherited in a recessive manner. If this is so, it can be expected that hybrids between bolting resistant and bolting susceptible parents will have a bolting tendency more like the bolting susceptible component.

Bolting at Phoenix, 1974-5

No.	Generation	% Bolting 4-1	4-8	4-15	4-22	4-29	% Non-bolters	No./25'
417-1		0.0	0.0	0.0	4.3	30.8	69.2	185
4203	P_1(C17)	0.2	0.6	2.6	14.7	46.9	53.1	252
4210	BCP_1	7.2	11.7	25.6	49.5	73.1	26.9	201
4204	F_2	3.4	6.2	15.3	38.7	62.5	37.5	255
4206	F_1	4.4	10.8	33.3	56.9	76.1	23.9	149
4211	BCP_2	21.9	28.4	47.2	66.0	87.3	12.7	162
4205	P_2(SP 6322-0)	11.0	20.6	37.0	57.8	80.0	20.0	281

Planted September 5, 1974. Plots were 25 ft. long. A completely random design was used with entries included 2 to 4 times. The test was grown under general seed-field conditions without being thinned. The obvious bolters were counted and removed at weekly intervals. After the April 29 count, the test was destroyed. Because of the heavy stands, some bolting may have been retarded and some bolters were not detected.

The Phoenix test was conducted in cooperation with Joe Pryor of Western Seed Production Corporation.

Bolting at Salem, 1974-5

No.	Generation	% Bolting 4-15	4-22	4-30	5-5	5-13	% Non-bolters	No./30'
417-1		4.5	24.1	57.3	87.3	98.6	1.4	110
4203	P_1(C17)	4.0	29.5	60.4	91.6	99.7	0.3	99
4210	BCP_1	9.4	43.7	86.2	99.1	100.0	0.0	112
4204	F_2	10.3	50.0	90.3	100.0	100.0	0.0	100
4206	F_1	11.3	45.2	85.2	99.1	100.0	0.0	115
4211	BCP_2	12.5	54.3	95.7	100.0	100.0	0.0	104
4205	P_2(SP 6322-0)	11.4	51.4	95.7	100.0	100.0	0.0	93

Planted September 7, 1974. Thinned to about 3 inch stands. Plots were 30 ft. long. A completely random design was used with entries included 2 to 4 times. Bolters were counted at approximately weekly intervals. After counting, bolted beets were removed.

The Salem test was conducted in cooperation with Sam Campbell of West Coast Beet Seed Company.

Bolting at Salinas, 1974-5

No.	Generation	% Bolting										% Non-bolters
		4-23	5-7	5-21	6-4	6-18	7-1	7-16	7-29	8-15	9-2	
417-1		0.0	0.0	0.0	0.0	1.0	2.0	2.0	3.9	4.9	4.9	95.1
4203	P_1(C17)	0.0	0.0	0.0	0.0	0.0	0.7	3.3	7.0	8.9	9.5	90.5
4210	BCP_1	0.0	0.0	5.0	26.9	44.6	51.0	64.5	68.7	69.3	71.2	28.8
4204	F_2	0.0	0.5	9.6	38.5	57.8	62.7	74.9	77.8	83.3	84.7	15.3
4206	F_1	0.0	0.0	2.3	18.6	45.2	61.9	74.5	77.3	80.5	81.6	18.4
4211	BCP_2	0.5	3.9	31.0	62.6	78.4	81.8	88.2	89.1	93.1	97.2	2.8
4205	P_2(SP 6322-0)	0.5	7.8	36.0	73.7	88.5	89.5	95.9	95.9	97.3	98.4	1.6

Planted November 20, 1974. Thinned to about 8 inch stands. Plots were 32 ft. long. A randomized block design with 4 replications and entries included from 1 to 4 times per replication was used. Bolters were counted at about 2 week intervals. Bolted beets were not removed, but stalks were occasionally cut back. Cultural practices were equivalent to those of other Salinas sugarbeet trials.

Fusarium Stalk Blight Resistance

by J. S. McFarlane

A premature death of bolting sugarbeet plants has been observed for several years in the Williamette Valley of Oregon. Dr. L. D. Leach and his assistant, J. D. MacDonald, have identified the causal agent as Fusarium oxysporum Sp. betae. Their research also established that a wide range in resistance exists among varieties and breeding lines. The monogerm, bolting resistant inbreds and their male sterile equivalents tended to be susceptible. The 562HO, 563HO, and 565HO lines were especially susceptible. In contrast, the multigerm NB 1 inbred from which these monogerm lines were developed through the backcross method showed good resistance. This suggested a possible linkage between the monogerm character and susceptibility to stalk blight. Some other monogerm lines were found by Leach and MacDonald to possess moderate-to-good resistance and this indicates that a linkage either does not exist or can be easily broken.

In cooperation with S. C. Campbell, work is underway to develop bolting resistant monogerm inbreds with good stalk blight resistance. A cross was made between the susceptible 562 inbred and the resistant NB 1 inbred. The hybrid was similar in resistance to the resistant parent (Table 2). Likewise, a cross between the susceptible 565HO and the resistant NB 4 inbred gave a resistant hybrid (Tables 1 and 2). These results indicate that resistance to stalk blight is dominant. An F_2 population from the 562 x NB 1 cross has been planted at Salem, Oregon, and an attempt will be made this next summer to select monogerm segregates with stalk-blight resistance.

Table 1
Fusarium Stalk Blight Resistance Test
Salem, Oregon, 1974-75

1 row plots, 50 ft. long — Planted: August 31, 1974; Rated: August 12, 1975

Entry	Description	Grade
2 replications		
464	Pollen parent US H7	0.71
868	US 75	0.99
1536-35	CTR inbred	0.97
1536-21	CTR inbred	1.52
Single plot		
4554	NB 4 inbred	0.26
2512	NB 6 inbred	0.71
2547	NB 5 inbred	1.47
2522-29	CTR inbred	2.06

Table 2
Fusarium Stalk Blight Resistance Test
Salem, Oregon, 1974-75
Cooperative with West Coast Beet Seed Company

4 replications
1 row plots, 50 ft. long

Planted: August 31, 1974
Rated: August 12, 1975

Entry	Description	Grade[1/]
4554H4	565H0 x NB 4	0.33
117T	Tetra C17	0.41
4554H1	NB 1(CMS) x NB 4	0.57
F70-17	C17	0.64
US H10B	546H3 x C17	0.97
4122Aa	562aa x NB 1	1.12
664H8	US H7	1.51
F63-546H0	546(CMS)	1.52
F66-563H0	563(CMS)	1.60
4539H8	546H3 x NB 8	1.65
3522-25	CTR inbred	1.71
F66-546H3	562(CMS) x 546	1.93
4502H4	564(CMS) x NB 1	1.94
3790H3	562(CMS) x 790	2.10
3789H3	562(CMS) x 789	2.21
3705H0	705(CMS)	2.38
F66-562H0	562(CMS)	2.48
F66-569H3	562(CMS) x 569	2.82
3536-97H0	536-97(CMS)	3.04
3718H0B	718(CMS)	3.15
3718H3(Sp)	562(CMS) x 718	3.15
3536-97H3	562(CMS) x 536-97	3.21
8522H1	564(CMS) x 522	3.35
3565H0	565(CMS)	3.68
3536-97	536-97(CMS)	3.84
3705H5	564(CMS) x 705	3.85
Mean		2.07
LSD (.05)		0.60
Coefficient of Variation (%)		20.50
F value		26.57**

1/ Stalk rot rated on a scale of 0 to 4 with 0 = no disease and 4 = dead plant; 100 plants of each entry were rated and the grades for the 100 plants were averaged.

Relationship of Age of Plants and Resistance to a Severe Isolate of the Beet Curly Top Virus

James E. Duffus and I. O. Skoyen

Beet curly top virtually destroyed the sugarbeet industry in the western United States prior to the introduction of resistant cultivars in 1934. The disease was the principal limiting factor for sugarbeet production west of the Rocky Mountains from the early 1900's until World War II.

Seeding early in the growing season (5, 10, 11)[1/], the use of resistant cultivars (3, 4), and insecticide application (2, 6, 9) have reduced these extremely heavy losses to less than catastrophic.

There is much evidence to indicate that beet curly top virus is a complex of strains that differ in virulence, symptoms induced, and host range. The last several years strains capable of causing marked damage on resistant cultivars of sugarbeet have increased in number and distribution. However, the extent of, and the implications of the actual damage and yield losses due to infection with the recently occurring severe isolates on sugarbeet cultivars has not been previously determined.

Field inoculation experiments with the curly top virus have been extremely difficult to conduct over the years and usually resulted in low infection rates in the inoculated plants and high contamination rates in the control plots. This, of course, has resulted in inaccurate estimates of the effects of curly top virus on sugarbeet yield. One of the more recently published papers on this subject (7) implies that little damage occurs on resistant cultivars when the plants are infected 4 to 5 weeks after planting.

The lack of information on the damage induced on resistant cultivars at different stages of plant development by the widespread virulent isolates of beet curly top virus prompted this study and preliminary studies during 1970 and 1973 (See Sugarbeet Research-1973 Report, pages A53-A56 and 1970 Report, pages B71-B73) which established a reliable inoculation technique that resulted in high levels of curly top infection, while uninoculated plots remained relatively free of curly top virus.

MATERIALS AND METHODS.--The sugarbeet cultivars US 75 and US 15 were seeded April 30, 1975 in a split-plot design with 5 replications, at the U.S. Agricultural Research Station, Salinas, California. The main plots were the two cultivars and the sub-plots were five dates of inoculation, approximately 4, 6, 8, 10, and 12 weeks after seeding and an uninoculated control. Dates of inoculation were completely randomized over each main plot. Sub-plot size was four rows, 4 meters long. Stands

1/ Refers to literature cited.

in each plot were reduced to 48 plants prior to the first inoculation. US 15, introduced in 1938, was the first cultivar to meet the requirements for winter sowing (bolting and curly top resistance) and was used in California for 10 years (8). It has what would be considered today low curly top resistance. US 75, introduced in 1952, has what is considered a high level of curly top and bolting resistance.

A severe isolate of the curly top virus (Logan) collected from Utah and as virulent as any isolate previously tested in California, was used in the inoculation.

Inoculations were made by attaching two small leaf cages containing three leafhoppers reared on virus infected plants, to the youngest leaves of the plants. The cages were made from 25mm diameter acrylic tubing covered at each end by nylon material and held tight to the leaf surface with bent hair clips. Cages remained on the inoculated plants for 1 week. Insect survival was over 90% during these inoculation periods.

The plants were examined at weekly intervals for curly top symptoms until harvest, October 15, 1975, when the plants were 24 weeks old.

RESULTS.--Percent infection.--Percentages of infection obtained at different intervals after seeding (Table 1) substantiated earlier results (1970, 1973, and 1974) (Skoyen & Duffus, unpublished) that the inoculation technique used results in high levels of curly top virus infection under field conditions. Infection percentages ranged from over 90% on the susceptible cultivar even after 8 weeks from seeding to 77.1% after 12 weeks. On the resistant cultivar, better than 95% infection was obtained even after six weeks, but infection percentages dropped to 38% after 12 weeks. These results indicate a significant increase of resistance to infection as the plants increase in size and/or age. There was no statistical difference in resistance to infection between the two cultivars in inoculations on the fourth and sixth weeks after seeding, but all inoculation after that time resulted in significantly lower infection rates for the resistant cultivar. The control plots at harvest time had 2% (resistant cultivar) and 8% (susceptible cultivar) curly top. This probably resulted from beet leafhoppers lost in the inoculation procedure and perhaps a few naturally occurring leafhoppers.

Yield.--Observations of the field plots and analysis of the yield data (Table 1) indicated that catastrophic losses could result in susceptible cultivars inoculated with current severe isolates of the curly top virus as late as 8 weeks after seeding. With the most resistant cultivars yield losses as high as 47.3% occurred with inoculations as late as 6 weeks after seeding. It is important to note that statistically significant yield losses (approximately 11%) resulted in the resistant variety inoculated as late as 10 weeks after seeding (after more than 40% of the growing period had elapsed).

Sucrose.--Analysis of the sucrose-content data indicated that curly top virus had a serious impact on the sugar content of infected, susceptible and resistant sugarbeets.

Sucrose content losses in the susceptible variety ranged from approximately 55% at the earliest inoculation date to approximately 3% at 12 weeks after seeding or after 50% of the growing period had elapsed. Sucrose losses in the resistant variety ranged from approximately 25% to about 3%.

Gross sugar.--Analysis of gross sugar data indicates that both yield components, root yield and sugar content played a significant role in the reductions caused by curly top. Early inoculations (through the fourth week from seeding) literally destroyed the sugar production of both susceptible and resistant cultivars. Resistance to yield loss and sucrose content increased rapidly in the resistant variety from the sixth week after seeding; however, inoculation at 10 weeks still resulted in a significant reduction of over 13% in sugar per acre.

Incubation period.--A statistical comparison of the incubation period of the beet curly top virus in a susceptible and resistant host showed several significant differences (Table 2). Both the average minimal incubation period and the average maximum incubation period were significantly different at the different stages of inoculation for both the susceptible and the resistant cultivars.

Incubation periods increase, in general at the successively later inoculation dates. The cultivars also differed significantly in incubation period. Both the average minimum and the average maximum incubation periods were longer for the resistant cultivar.

Disease index.--Statistical analysis of the incubation period data showed highly significant correlations between the incubation periods and the yield components--yield, sucrose content and gross sugar. Visual observations and statistical analysis of the diseased plants in the field showed a highly significant correlation between the length of time the plants were showing symptoms and the final yield of sucrose per acre. A disease index--computed by multiplying the percentage of plants showing symptoms times the number of weeks until harvest, was calculated for each replicate and each inoculation date for both cultivars. Regression coefficients of the loss of sucrose yields on the disease index are shown in Fig. 1. They indicate that for each increase of one unit of the disease index there was a decrease of 7.75% of the possible sugar per acre for US 15, and of 6.01% sugar per acre for US 75. Both regression coefficients are highly significant and the slopes are significantly different from each other.

DISCUSSION.--The avoidance of infection during the early part of the growing season has long been recognized as an important factor in preventing excessive losses from beet curly top virus in regions where the disease is prevalent. With the development of resistant cultivars the prevention of early infection was assumed to be less urgent. During the last 20 years, curly top virus isolates have increased in severity to the point that isolates then considered severe are now considered mild. The conclusions based on age of infection studies conducted during the 1940's are no longer valid and could seriously mislead sugarbeet growers and processors. The implication that little damage occurs on resistant cultivars when the plants are infected 4 to 5 weeks after seeding is no longer true with the new virulent isolates of the curly top virus. The ability of modern curly top resistant cultivars to withstand infection and injury from curly top, and to outgrow distinct evidence of injury, even when infected at a young stage of growth, as was reported in the 1940's, is not possible with the curly top isolates of today. Although the curly top virus has been extensively studied since it was first reported in 1888, and has caused severe and extensive losses, little has been known about actual losses induced by the virus.

The, still not infrequent, destructive attacks of the curly top virus which make headlines, are probably not as important economically as the generally accepted curly top infection at later stages of plant development. The fact that infection of the most resistant commercial cultivars with commonly occurring curly top isolates, even 10 weeks after seeding, caused losses of over 13%, indicates the need for more effective control measures.

Disease loss at later stages in plant development has probably been underestimated or overlooked because of the lack of contrast with disease free plants. This has been the result of high curly top incidence and using inadequate inoculation techniques.

The lack of a satisfactory field inoculation technique, for instance, has led to the assumption in the curly top literature that although roots of diseased plants tend to be woody, sucrose percentages appear to be unaffected (1). It is clearly evident in the preliminary experiments (Sugarbeet Research-1970 Report and 1973 Report) and in the present work that the current virulent isolates of the curly top virus have a serious impact on the sugar content of both susceptible and resistant sugarbeet cultivars.

Losses of over 13% in gross sugar occurred in the resistant cultivar even with inoculations 10 weeks after seeding. It should be pointed out that these losses were the result of only 72.1% of the plants showing symptoms. In areas of high leafhopper incidence, the percentage of infected plants would undoubtedly approach 100% with resulting greater losses.

Analysis of the incubation period data indicated significant differences between the susceptible and resistant cultivars in both minimum and maximum incubation periods. When the incubation periods resulting from the different inoculation dates were plotted on a graph (Fig. 2), it became obvious that these increasing incubation periods at the later inoculation dates were probably the most significant factor in disease resistance. A disease index, the time the plants showed symptoms until harvest, was highly correlated with the percent loss in gross sugar yield. Interestingly, although the slopes for the susceptible and resistant cultivars were statistically different, they are remarkably similar for cultivars differing so greatly in resistance. There is little evidence that resistance cultivars show any tendency toward recovery, as far as yield factors are concerned.

A reasonable estimate of loss of sucrose due to effects of severe isolates of beet curly top virus could be derived from these regression coefficients for essentially the range of resistance of sugarbeet cultivars.

TABLE 1. Effects of a severe isolate of the beet curly top virus on resistant and susceptible sugarbeet cultivars inoculated at different intervals after seeding.

Time of inoculation (weeks after seeding)	Infection[2] (%)	Yield of beets/ha (metric tons)	Sucrose (%)	Gross sugar/ha (kg)
US 15 (Susceptible)				
4	98.3 a[1]	0.16 a	6.71 a	11 a
6	99.7 a	11.34 b	10.78 b	1,222 b
8	94.3 a	34.04 c	12.91 c	4,415 c
10	84.6 b	52.49 d	14.08 d	7,386 d
12	77.1 b	54.04 d	14.75 de	7,993 de
No inoculation (control)	8.3 c	57.01 d	15.18 e	8,663 e
US 75 (Resistant)				
4	95.4 a	3.27 a	11.42 a	377 a
6	96.5 a	35.99 b	13.35 b	4,818 b
8	77.2 b	58.31 c	14.45 c	8,440 c
10	72.1 b	60.90 c	14.90 cd	9,076 c
12	38.4 c	68.09 d	14.88 cd	10,135 d
No inoculation (control)	2.1 d	68.34 d	15.35 d	10,496 d

1/ Means within columns followed by the same letter are not significantly different from each other at the 5% level (Duncan's multiple range test).

2/ LSD, 5% between cultivars for % infection at different times of inoculation = 8.03.

TABLE 2. Incubation periods of a severe isolate of the beet curly top virus on resistant and susceptible sugarbeet cultivars inoculated at different intervals after seeding.

Time of inoculation (weeks after seeding)	US 15 (susceptible)		US 75 (resistant)	
	Minimum[2/] incubation period (weeks)	Time for maximum % infection (weeks)	Minimum incubation period (weeks)	Time for maximum % infection (weeks)
4	2.0 a[1/]	2.0 a	2.0 a	2.8 a
6	2.0 a	5.5 b	3.0 b	8.6 b
8	2.4 ab	7.4 c	4.6 c	11.1 c
10	3.2 bc	8.7 cd	4.3 c	10.7 c
12	3.6 c	9.3 d	5.9 d	9.5 bc

1/ Means within columns followed by the same letter are not significantly different from each other at the 5% level (Duncan's multiple range test).

2/ LSD, % between cultivars for minimum incubation period = .86, and for maximum % infection = 1.65 at different times of inoculation.

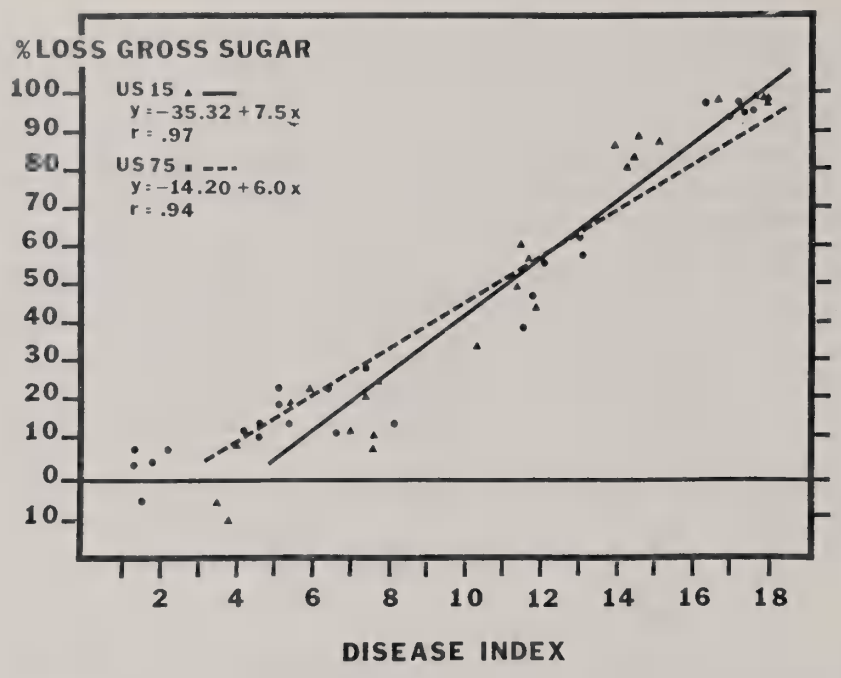

Fig. 1. Relationship between disease index (the time the plants showed symptoms until harvest) and loss of gross sugar.

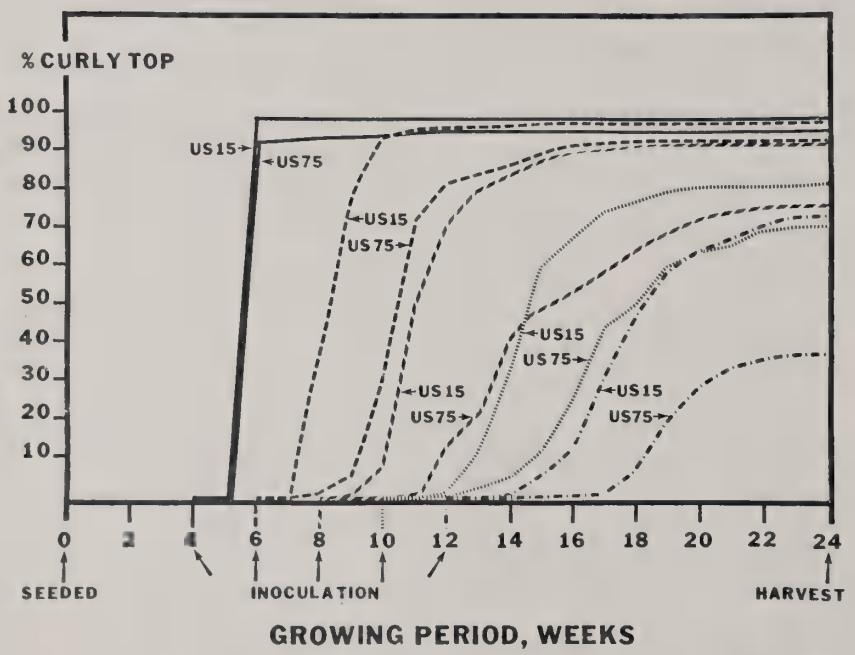

Fig. 2. Curly top development as expressed by symptom expression resulting from five inoculation dates during the growing season.

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NEMATOLOGY STUDIES

Results of 1975 tests of aldicarb with various carriers for control of Heterodera schachtii on sugarbeet.

Arnold E. Steele and Antoine Puech

A test of 10 treatments was replicated 5 times in a randomized complete-block design in a field of sandy loam soil infested with Heterodera schachtii. Nematode counts averaged 46 cysts with viable eggs/100 grams of soil. The 1974 sugarbeet crop in this field was a total loss due to sugarbeet nematode. Plots consisted of 4 beds spaced 40 inches apart and 125 feet long with 2 rows per bed. Granular formulations of aldicarb were applied at rates of 2 or 4 lbs a.i/A in a 3-4 inch band 4 inches below the soil surface (2-3 inches below the prepared seed row). Carriers included corn cob, bituminous coal, or on gypsum which held 10 or 15 percent aldicarb. Aldicarb sulfone (UC 2186) was also applied before planting as a wettable powder at 5 lb a.i/A. Soil pH was 7.2 and soil temperature was 55 F at time of treatment. Beets were planted on April 31 and the field sprinkler irrigated on April 16. Beets were thinned on June 2. Aldicarb with various carriers was also applied June 3 as sidedress treatments of 2 lb a.i/A on the furrow side of the row 3-4 inches below the soil surface. Pyramin was applied at .75 lb/A for pre-emergence and early post-emergence weed control. Plant samples were obtained to evaluate nematode control on July 8. Beets were harvested October 17-18. The two and four pound rates of aldicarb applied before planting significantly reduced nematodes in roots of sugarbeet by thinning time regardless of the carrier employed. Six weeks after application of the second treatments of 2 lbs a.i aldicarb, only plants from plots treated with Temik 15G on gypsum (2 + 2) or UC 21865 had nematode counts not significantly lower than untreated checks. Although beets were planted 4 months after the usual planting date for beets in the Salinas Valley, yields of beets and sugar reflect performance of the nematicides. The data of this test and results of laboratory and greenhouse studies indicate that aldicarb sulfone (UC 21865) does not control Heterodera schachtii on sugarbeet.

Table 1. Efficacies of Nematicides for Control of Heterodera schachtii

Treatment	Samples Taken 44 Days After Planting				Samples Taken 86 Days After Planting			
	Top Weights g	Root Weights g	Total Weights g	Adult Nematodes	Top Weights kg	Roots Weights kg	Total Weights kg	Adult Nematodes
Temik 15 G-Corn 4 lb	102.2 [1/]	8.8	111.0	23.4	3.17	1.32	4.49	167.4
Temik 15 G-Corn 2 + 2 [2/]	71.7	5.6	77.3	33.6	3.00	1.13	4.13	143.4
Temik 10 G BC 4 lb	116.5	8.8	125.3	21.6	2.72	1.13	3.67	221.2
Temik 10 G BC 2 + 2 [2/]	64.6	4.7	69.3	38.0	2.63	1.00	3.63	207.0
Temik 10 G-Gypsum 4 lb	81.0	6.9	87.9	15.0	3.08	1.04	4.49	209.0
Temik 10 G-Gypsum 2 + 2 [2/]	95.9	8.8	104.7	46.6	2.63	1.00	3.63	255.5
Temik 15 G-Gypsum 4 lb	69.4	6.4	75.8	22.4	2.81	1.00	3.81	255.4
Temik 15 G-Gypsum 2 + 2 [2/]	70.5	6.0	76.5	57.4	2.22	0.73	2.95	436.8
UC 2186 5 lb	31.9	3.2	35.1	138.0	2.13	0.64	2.77	636.6
Check	19.1	2.1	21.2	152.4	0.50	0.18	0.68	578.6
Significance	-	**	**	**	-	**	**	**
LSD .05	-	3.8	53.4	50.8	-	0.54	1.63	240.3

[1/] Each figure represents means of 5 replications. Each replication includes 10 plants sampled at random.

[2/] Two pounds active applied before planting followed by 2 lbs active applied after thinning. All other treatments are single preplant applications.

Table 2. Harvest Data - Aldicarb Carriers, Turri Ranch, Chualar, California 1975

Treatment	% Clean Beets	Lbs. Clean Beets[1]	Tons Beets/ Acre	% Sucrose	Lbs. Sugar/ Plot[1]	Tons Sugar/ Acre
Temik 15 G-Corn 4 lb	92.9[2]	575	15.0	13.9	80.19	2.10
Temik 15 G-Corn 2 + 2[3]	90.6	618	16.2	14.1	87.14	2.28
Temik 10 G BC 4 lb	90.6	613	16.0	14.1	86.73	2.27
Temik 10 G BC 2 + 2[3]	91.1	578	15.1	14.7	84.80	2.22
Temik 10 G-Gypsum 4 lb	90.4	617	16.1	14.4	88.91	2.32
Temik 10 G-Gypsum 2 + 2[3]	91.7	619	16.2	14.8	91.39	2.39
Temik 15 G-Gypsum 4 lb	90.7	570	14.9	14.0	80.09	2.09
Temik 15 G-Gypsum 2 + 2[3]	88.1	479	12.5	14.0	67.17	1.76
UC 21865 5 lb	89.9	344	9.0	13.6	46.95	1.23
Check	87.0	104	2.7	14.5	15.12	0.40
Significance	-	**	**	-	**	**
LSD .05	-	188	4.9	-	25.63	0.67

[1] Beets harvested from 125 feet of 2 inside beds (500 feet of row) on October 17-18, 1975.

[2] Each figure is the mean of 5 replications (plots).

[3] Two pounds active applied before planting followed by 2 lbs active applied after thinning. All other treatments are single preplant applications.

Results of 1975 tests of nematicides for control of *Heterodera schachtii* on sugarbeet.

A. E. Steele, W. H. Hart, and G. Wheatley

A test of 10 treatments was replicated 5 times in a randomized complete-block design in a field of sandy loam soil infested with *Heterodera schachtii*. Nematode counts averaged 46 cysts with viable eggs/100 grams of soil. The 1974 sugarbeet crop in this field was a total loss due to sugarbeet nematode. Plots consisted of 4 beds spaced 40 inches apart and 125 feet long with 2 rows per bed. Temik 15G, Furadan 10G, Nemacur 15G and Dasanit 15G were applied before planting on April 2-3, 1975. Granular formulations were applied at rates of 2, 4 or 6 lbs a.i/A in a 3-4 inch band 4 inches below the soil surface (2-3 inches below the prepared seed row). Soil pH was 7.2 and soil temperature was 55 F at time of treatment. Beets were planted on April 31 and the field sprinkler irrigated on April 16. Beets were thinned on June 2. Temik 15G, Furadan 10G and Nemacur 15G were also applied June 3 as sidedress treatments of 2 lb a.i/A on the furrow side of the row 3-4 inches below the soil surface. Pyramin was applied at .75 lb/A for pre-emergence and early post-emergence weed control. Plant samples were obtained to evaluate nematode control on July 8. Beets were harvested October 17-18.

Dasanit was extremely phytotoxic to sugarbeet. Soon after emergence, seedlings were stunted, leaves were laterally twisted and thickened with dark green color except for marginal chlorosis. Reduced plant growth during the season in plots treated with Dasanit and non-treated plots were reflected in yields of beets and sugar. Although nematode counts of treated plots were not significantly different, the 4 lb a.i/A rate of Temik, Furadan and Nemacur gave the best nematode control when applied before planting.

Information on nematicides evaluated:

1) Dasanit 15G - (Pensulfothion) O,O-Diethyl O- p-(methylsulfinyl) phenyl phosphorothioate. Chemagro Div., Baychem Corp., Kansas City, Kansas.

2) Furadan 10G - (Carbofuran) 2,3-Dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate. Niagara Chemical Div., FMC Corp., Middleport, N.Y.

3) Nemacur 15G - (Phenamiphos) Ethyl 4-(methylthio)-m-tolyl isopropylphosphoramidate. Chemagro Div., Baychem Corp., Kansas City, Kansas.

4) Temik 15G - (Aldicarb) 2-Methyl-2-(methylthio)propionaldehyde O-(methylcarbamoyl)oxime. Union Carbide Corp., New York, N.Y.

Table 3. Efficacies of Nematicides for Control of Heterodera schachtii.

Treatment and rate/ acre (active)	Samples Taken 44 Days After Planting				Samples Taken 86 Days After Planting			
	Top weights (g)	Root weights (g)	Total weights (g)	Adult nema-todes	Top weights (g)	Root weights (g)	Total weights (g)	Adult nema-todes
Temik 15G 4 lb	137.1[1/]	11.2	148.3 a	13.4 b	4.71	1.91 a	6.62 a	97.2 b
Temik 15G 2 lb	136.2	11.6	147.8 a	16.2 b	3.85	1.50 ab	5.35 ab	151.0 b
Temik 15G 2 lb + 2 lb[1/]	116.4	9.6	126.0 ab	67.0 b	4.40	1.32 ab	5.72 ab	112.0 b
Furadan 10G 4 lb	125.8	10.3	136.1 ab	8.2 b	3.86	1.45 ab	5.31 ab	79.6 b
Furadan 10G 6 lb	101.8	8.8	110.6 abc	9.8 b	3.85	1.32 ab	5.17 ab	17.2 b
Furadan 10G 2 lb + 2 lb[1/]	122.7	10.2	132.9 ab	9.6 b	3.77	1.36 ab	5.13 ab	144.6 b
Nemacur 15G 4 lb	88.0	8.0	96.0 abc	36.8 b	4.21	1.41 ab	5.62 ab	63.0 b
Nemacur 15G 2 lb + 2 lb[1/]	103.5	9.6	113.1 abc	16.8 b	3.13	1.13 bc	4.26 bc	108.0 b
Dasanit 15G 4 lb	40.2	2.9	43.1 c	9.4 b	2.09	0.59 cd	2.68 c	111.6 b
Untreated check	62.7	6.2	68.9 bc	185.4 a	1.09	0.32 d	1.41 d	1538.4 a

[1/] Two pounds active applied before planting followed by 2 lbs active applied after thinning. All other treatments are single preplant applications.

[2/] Each figure represents means of 5 replications. Each replication included 10 plants sampled at random from the inside 2 beds at 44 days and from the outside beds 86 days after planting. The small letters indicate Duncan's multiple range groupings of treatments which do not differ significantly at the 5% level.

Table 4. Effects of nematicides on yields of beets and sugar.

Treatment and rate/ acre (active)	At harvest stand counts[1]	Percent clean beets	Lbs. clean beets/plot[2]	Tons beets/ acre	Mean percent sucrose	Lbs. sugar/ plot[2]	Tons sugar/ acre
Temik 15G 4 lb	265[4]	91.3	730 a	19.1 a	13.5	98.74 a	2.58 a
Temik 15G 2 lb	251	89.7	661 abc	17.3 abc	13.7	90.58 ab	2.37 ab
Temik 15G 2 lb + 2 lb[3]	264	90.8	680 ab	17.8 ab	13.4	91.22 ab	2.38 ab
Furadan 10G 4	286	88.3	622 abc	16.3 abc	14.6	90.61 ab	2.37 ab
Furadan 10G 6	243	89.7	612 abc	16.0 abc	13.3	81.32 ab	2.13 ab
Furadan 10G 2 lb + 2 lb[3]	281	89.9	578 bc	15.1 bc	12.6	73.05 b	1.91 b
Nemacur 15G 4 lb	271	89.7	626 abc	16.3 abc	14.5	90.50 ab	2.37 ab
Nemacur 15G 2 lb + 2 lb[3]	252	90.0	530 c	13.9 c	14.5	76.89 b	2.01 b
Dasanit 15G 4 lb	204	83.7	384 d	10.0 d	14.2	54.32 c	1.42 c
Untreated check	222	81.0	180 e	4.7 e	13.3	23.91 d	0.62 d

[1] Stand counts taken from 50 feet of 2 inside beds (200 feet of row).

[2] Beets harvested from 125 feet of 2 inside beds (500 feet of row) on October 17-18, 1975.

[3] Two pounds active applied before planting followed by 2 lbs active applied after thinning. All other treatments are single preplant applications.

[4] Each figure is the mean of 5 replications (plots). The small letters indicate Duncan's multiple range groupings of treatments which do not differ significantly at the 5% level.

HATCH FACTOR PROJECT

Because of the protective nature of the cyst, the sugarbeet nematode may remain dormant within the soil for longer than 12 years. In moderate climates the populations decline by one-half each year. The method of nematode control on sugarbeet most frequently used by growers today is rotation of sugarbeet or other host crops with non-host crops. On nematode-infested land, host crops are not grown more often than once in three to four years. Growers also plant early while soil temperatures are low to achieve early growth and plant vigor while nematodes are inactive. However, these measures do not ensure the grower against losses, particularly on leased land where previous crop history is not known. Benefits of early planting are often negated by environmental factors and occasionally by the need to replant. In some areas, limited crop variety makes rotation an unsatisfactory control measure.

One method of control that can be used, is to stimulate hatching and emergence of larvae from cysts during fallow periods or when non-host crops are grown. The emerged larvae, unable to find a host plant, would die soon after using up its food reserves (within one growing season). Hatch-inducing materials are normally present in diffusates of rapidly growing sugarbeet seedlings. The isolation, identification and possible synthesis of the hatch factors may enable control without the use of nematicides or the materials could be used to enhance the efficacies of nematicides and perhaps lower the rates required for control. Identification of hatch factors may also lead to other compounds already on the shelf that have hatching properties and could simplify the search for hatch factors with cyst nematodes parasitic on other crops, i.e., the golden nematode of potato and the soy bean cyst nematode.

Cooperative efforts to isolate and identify the hatch factor are underway at the Western Regional Research Laboratories at Berkeley and Salinas, California. Diffusate that is dried by vacuum distillation is chemically fractioned at Berkeley and the fractions bioassayed for hatching activity at Salinas. With a grant of assistance by the Beet Sugar Development Foundation, we were able to employ a full-time technician to conduct bioassays of 2,410 samples during 1975.

We have quantititavely traced the hatch factor and have isolated the compound in nearly a pure state and are now in the process of attempting to obtain the material in an absolutely pure form for final structural analysis. The hatch factor appears to be an acidic compound containing sulfur and nitrogen with a molecular weight between 3000 and 4000.

Cooperators: A. E. Steele and Achem Burkhardt.

Laboratory screening of experimental nematicides for control of *Heterodera schachtii*

Aqueous solutions of carbofuran (2,3-Dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate) supplied by Niagara Chemical Div., FMC Corp., Middleport, N.Y., and AC 64,475 (2-[Diethoxyphosphinylimino] -1,3-dithietane) supplied by American Cynamid Company, Princeton, N.J., were tested for lethal effects on unhatched larvae of *Heterodera schachtii*. Concentrations tested were: 0.1, 0.5, 1, 5, 10, 50, 100 and 500 µg/ml. Cysts obtained from infected sugarbeet grown in a greenhouse were treated 4 days with nematicide solutions, and placed in several changes of tap water during a period of 4 days to remove the nematicides. The cysts were then treated 4 weeks with sugarbeet root diffusate to stimulate hatching and emergence of larvae as a means of assessing the effects of the chemical treatments. Counts of emerged larvae are listed on Table 5.

Although hatching was stimulated by lower concentrations of nematicides, 50 µg/ml carbofuran and 100 µg/ml AC 64,475 completely inhibited hatching. However, the greatest hatches were obtained from cysts treated with 50, 100 or 500 µg/ml carbofuran when these cysts were later treated with diffusate. Only treatments of 500 µg/ml AC 64,475 resulted in a permanent reduction of hatching.

Table 5. Influence of carbofuran and AC 64,475 on hatching and emergence of larvae from cysts of Heterodera schachtii.[1/]

Treatment Chemical	Concentration (µg/ml)	Mean no. larvae in chem.	Mean no. larvae in water	Mean no. larvae in diffusate	Mean larval emergence[3/]
Carbofuran	0.1	112[2/] b[4/]	4[2/]	228[2/]	344 de[4/]
	0.5	67 b	1	227	295 def
	1	29 cd	0	239	268 def
	5	19 cd	2	258	279 def
	10	8 cd	21	473	502 cd
	50	0 d	3	613	616 bc
	100	0 d	2	1088	1090 a
	500	0 d	1	799	800 b
AC 64,475	0.1	40 b	0	158	198 ef
	0.5	80 bc	0	158	238 def
	1	63 bcd	0	100	163 ef
	5	57 bcd	8	228	293 def
	10	26 cd	7	260	293 def
	50	3 cd	23	473	499 cd
	100	0 d	1	406	407 cde
	500	0 d	0	31	31 f
Tap water	--	18 cd	3	191	212 def
Diffusate	--	500 a	63	41	603 bc

[1/] Cysts treated 1 week in chemical, 4 days in water and 4 weeks in sugarbeet root diffusate.

[2/] Mean numbers of larvae emerged from 5 replications of 20 cysts.

[3/] Value includes larvae emerged in chemical, water and diffusate.

[4/] Small letters indicate Duncan's multiple range groupings of treatments which do not differ significantly at $P = 0.05$.

SUGARBEET RESEARCH

1975 Report

Section B

Crops Research Laboratory, Logan, Utah

Dr. D. L. Doney, Geneticist
Dr. D. L. Mumford, Plant Pathologist
Dr. J. C. Theurer, Geneticist
Dr. R. E. Wyse, Plant Physiologist

Cooperation:

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The research was supported in part by funds provided through the Beet Sugar Development Foundation (Projects 27, 64, and 69).

CONTENTS

VARIETY TESTS, LOGAN AND FARMINGTON, UTAH, 1975

J. C. Theurer, D. L. Doney, D. L. Mumford

SOIL TYPES: North Farm: Silty loam.
Farmington Farm: Sandy loam.

FERTILIZER: North Farm: 650 pounds per acre of 16-20-0.
Farmington Farm: " " " " "

PLANTING DATES: North Farm: May 12 and 13, 1975.
Farmington Farm: May 2, 1975.
(Majority of tests at both farms were planted in 2-row plots 38 feet long.)

THINNING DATES: North Farm: June 16-20, 1975.
Farmington Farm: May 3-6, 1975.

IRRIGATIONS: North Farm: Sprinkled after planting, after thinning, and at weekly intervals until two weeks prior to harvest.

Farmington Farm: Furrow irrigated after thinning and at weekly intervals to keep the field moist until three weeks prior to harvest.

HARVEST DATES AND PROCEDURES: North Farm: October 30 - November 4, 1975.

Farmington Farm: October 17-22, 1975.

Tops were removed by beating twice with a rotobeater, then topped and harvested with a two-row harvester. Beets in plots were counted into the weighing basket on the harvester. A 10-beet sample was taken at random from the harvester table from each row of the 2-row plots for sugar analysis, and all beets in the plot were weighed to determine root yield.

VARIETY TEST 1

The prime objective of this test was to evaluate a diallel cross among eight inbreds for storage respiration for the second year. This was a means of further substantiating the performance data found in 1973 and 1974 for these inbreds and hybrids and determining the relative association of respiration rate with root yield and sugar percentage.

Since few differences were observed in 1974 in the performance of reciprocal crosses and between equivalent inbreds, reciprocals were not included in the test this year, nor were the CMS inbred equivalents. The entries consisted of 9 inbreds, 36 hybrids, and 7 commercial check varieties. The F.C. 506 inbred (F6) and crosses with this inbred were not included in the 1974 experiment because of lack of sufficient seed for some of the crosses. The entries were planted in six replicates of two-row plots 38 feet long at the North Farm in Logan.

Table 1-1 shows the root yield, sugar percentage, and impurity factors for the 9x9 diallel. The check variety GWD2 was significantly superior to all but two entries in root weight and significantly superior to all but four crosses in gross sugar. L53, L29, and E1 inbreds showed the same tendency for general combining ability in hybrids for root weight as observed in the previous years. L33 and F6 hybrids were poor in gross sugar on the average. L29 showed good yield as an inbred in contrast to L53. This year's data substantiate again that progeny testing is the only way to determine the potential of an inbred for its yield contribution to a hybrid.

The L53 inbred had the highest sugar percentage in the test (16.3%). L53, E131, A4, and A5 hybrids were inbreds that gave better than average sugar percent in their hybrids. L29, A1, and F4 were low in combining ability for sugar percent.

Tables 1-2 to 1-8 show the diallel analysis and heterosis for sugar yield, root yield, sugar content, and quality factors.

Both general and specific combining ability were highly significant for sugar yield, root yield, impurity index values, nitrogen, sodium, and potassium. Only general combining ability F ratios showed significance for sugar percent.

All inbreds showed significant heterosis for gross sugar and root yield, with L53 exhibiting the greatest heterosis. L29, L33, A4, E1, and F4 exhibited heterosis for sugar percent. L29, L33, A1, and F4 had significant heterosis for low impurity indices. L53, A4, A5, and F6 showed heterosis for higher impurity indices.

Comparison of 1974 and 1975 data indicated there were both similarities and significant differences in performance. The hybrids behaved quite similarly; for example, those with L53, L29, and E1 parentage produced high gross sugar each year, and L33 and A4 hybrids

were the lowest in gross sugar each year. The inbreds F4, A1, A4, and A5 showed similar ranking for the two years, but the other inbreds showed a significant interaction with years. The general and specific combining ability F ratios and the magnitude of general-to-specific combining ability was very similar for 1974 and 1975 field trials. However, general combining ability was greater in 1974, and the specific combining ability F ratio was greater in 1975 for root yield and sugar yield. The F ratio for general combining ability in 1975 and the potassium in 1974 was significantly lower than the values for the other year of evaluation. Data on respiration will be given in a later section of the Logan report.

VARIETY TEST 2

Variety Test 2 was designed for growth analysis study and will be found in a later section of the Logan report.

VARIETY TEST 3

Potential new pollinator inbreds were crossed with selected CMS lines and evaluated in conjunction with several commercial varieties. The test consisted of 39 entries, 26 of which were single-cross experimental hybrids, and the balance were commercial varieties. The planting was made at Farmington, Utah, in 2-row plots 38 feet long and with six replications.

Performance data are shown in Table 3. As observed in other tests this year, GWD2 was the most productive variety in the test. This variety was significantly superior in gross sugar to all but seven entries tested.

Four experimental hybrids--L53XC13, A4X73708, C1XP3, and L53X908A--significantly exceeded the mean and showed specific combining ability for gross sugar and beet yield. A4XP3 and F6XP3 were significantly better than the mean and showed specific combining ability for percent sugar. C13 gave good root yield with L53 and L33 inbreds, but sugar percent was low for C13 hybrids. Inbred 73708 gave excellent tonnage with A4 and L33 but showed poor combining ability for yield with L53, A5, and F4 inbreds. P3 combined well with C1, fair with L33 and L53, and poor with A4, A5, and F6 for root yield. This inbred showed good general and specific combining ability for sugar percent. The inbreds 908A and 1512 were tested in crosses with only two inbreds. Yield of beets was excellent in the L53 crosses but poor with L33 parentage. Sugar percent was average for 908A, while inbred 1512 showed good combining ability for high sugar percent. Inbreds 0506-7 and 73702 showed little merit for root yield or sugar percent; however, hybrids having these lines as parents averaged the lowest impurity indices in the test.

VARIETY TESTS 4 AND 5

Over the past decade, experimental varieties have been developed and tested at Logan, and comparison has been made with one or two commercial varieties as checks.

We felt it would be of interest to compare the performance of the best experimental hybrids developed at Logan with the major varieties used in commercial production today. Twenty-six entries were included in the test: 11 Logan experimental hybrids, 9 commercial hybrids, 5 experimental hybrids from Dr. Kent Nielson, UI Sugar, and the standard check US22/3. The entries were planted in six replicates of a random block design at Logan and Farmington. Individual plots were two rows wide and 38 feet long.

The yield, sucrose percentage, and quality factors are given in Table 4 for the Logan test and in Table 5 for the Farmington test. Of all of the varieties at both locations, GWD2 had the highest gross sugar. This variety was significantly better than all but ten entries at Logan and all but four at Farmington. At both locations, Logan experimental varieties having L33xL5 and L37 in their parentage were among top varieties for root weight and gross sugar. Commercial varieties with the lowest impurity index were UI-7 and AH4. The commercials with the highest impurity index value were USH10B, GWD2, and US22/3.

A comparison between US22/3 and other entries allows breeders to visualize the progress made in hybrid performance since it was used as a major commercial variety in United States. At the Logan location (Table 4), two commercials and four Logan experimental hybrids were significantly superior to US22/3 for gross sugar. Only one commercial, GWD2, was significantly better in tonnage, and none were superior in sugar percentage. Four of the Logan experimental hybrids significantly exceeded US22/3 in tonnage, and five were superior in sugar percentage. At the Farmington location (Table 5), eight commercial varieties exceeded significantly US22/3 for gross sugar and tonnage, but none was superior for sugar percentage.

For the Logan experimental hybrids, nine were significantly higher than US22/3 for gross sugar; seven were superior for tonnage and sugar percentage.

It is evident that considerable progress has been made in improvement of yield of beets in commercial varieties in the last thirty years. However, there has been little change made for improving sugar content.

VARIETY TEST 6

At Logan this year, thirty-two inbreds were evaluated in 2-row plots 38 feet long with four replicates.

Root yield, percent sugar, and quality factors are given in Table 6. The C13 inbred had the highest root weight but was also one of the lowest inbreds in percent sugar. L9 had both high yield and high sugar percentage. FC506 was highest in gross sugar yield. As anticipated, L19 was significantly superior to all other inbreds for percent sugar and ranked fifteenth (average) in root yield. FC504 and LRf-1 inbreds were significantly low in sugar percentage and yield. Inbred 74519 had 16.79 percent sugar and was second highest in the test for this character. This inbred has L19 in its parentage which, no doubt, accounts for its high percent sugar. The other inbreds that showed good promise as parents for increasing sugar percent were 74515, 74518, L8, and L53. L18 did not show as high sugar percentage as expected from previous years' evaluations of inbreds.

VARIETY TEST 7

In 1974, differences were noted in the Farmington test plots for susceptibility to powdery mildew infection. L37 showed less effects from the disease than CT8 and other inbred lines. This test was established to obtain data on the effects of powdery mildew on yield and sugar percentage in the intermountain area. The varieties selected for the test were single crosses of inbreds L37, L53, and L29 that had good general combining ability for yield, and hybrids of A4 and L19 inbreds that contributed to high sugar percentage. L35 hybrids were also included since information last year indicated that curly top resistant lines were relatively susceptible to mildew. Sixteen hybrids, the eight inbred parents, and two checks, US33, and an experimental variety, 8193, that showed heavy infection in Farmington plots in 1974, were included in the experiment. Entries were planted in six replicates of a split-plot random-block design with 2-row plots 36 feet long. Originally, it was planned that one-half of each plot would be treated with sulfur when mildew was first observed in the plot to determine the effect of mildew on yield. However, the incidence of the disease was so late in moving into the area that we felt there was notsufficient time for yield differences due to the disease to be manifest. Thus, sulfur treatments were not made.

The comparative yield and sugar content of the varieties and inbreds in the test are given in Table 7-1. The yield of roots was as expected in that L53XL37 was the highest yielding variety. Other hybrids with these inbreds as parents had the greatest tonnage and, consequently, the highest yield of gross sugar. In sugar percentage, L19XA4 was highest, and hybrids with these inbreds and L53, which

also had general combining ability for sugar content, were the better entries for this character. A4, A7135, and L37 were the inbreds having the highest root weight. L19 was significantly better in sugar percentage than any other entry. L53, A4, and A7112 were other inbreds with relatively high sugar percentage.

Readings were made by Dr. David Mumford on powdery mildew infection on September 15, 1975. Entries were classified on a scale of 1 to 5 in which 1 = resistant and 5 = highly susceptible. The analysis of variance showed highly significant F values for males, females, and males x females (Table 7-2). Means of the disease readings are given in Table 7-3. L37 was significantly more resistant than any other inbred in the test. A7112 was significantly the most susceptible inbred. There were also significant differences between hybrids for mildew infection. The L37 hybrids had a mean score of 1.37 which demonstrated excellent combining ability of the L37 inbred with all female parents for powdery mildew resistance.

A comparison of the hybrid means with the mid-parent means of the inbred parents gave an estimate of heterosis (Table 7-4). Both additive and non-additive gene actions were apparent for powdery mildew resistance. L37 showed highly significant heterosis and L29 and A7112 were significant at the 5 percent level for increased mildew resistance. Inbred L19 showed highly significant heterosis for susceptibility to mildew.

Table 1-1. Yield sugar percentage and quality factors for hybrids and inbreds in a 9x9 diallel. Logan, Utah 1975

Description	Acre Yield		Percent	PPM			
	Gross Sugar (Lbs)	Tons Beets	Sugar	Index	N	Na	K
GWD2	9603	31.43	15.30	735	666	125	1646
E1 X L53	9362	29.81	15.69	717	675	160	1553
F4 X L53	9045	29.64	15.23	782	651	292	1722
A4 X E1	8720	27.36	15.94	635	597	133	1469
A1 X L53	8701	28.41	15.31	720	719	134	1307
E1 X L29	8685	27.80	15.65	602	540	126	1429
L53 X L29	8670	28.41	15.26	688	639	149	1427
F4 X L29	8633	28.63	15.02	611	462	172	1562
E1 X A1	8623	28.49	15.16	761	735	120	1446
U1 8	8617	28.16	15.30	619	555	134	1389
A5 X E1	8517	26.65	16.02	606	485	160	1686
L53 X L33	8407	27.22	15.42	627	585	188	1256
A5 X L53	8365	26.65	15.69	748	673	180	1743
F6 X L53	8312	27.09	15.30	755	716	206	1414
U1 7	8304	27.50	15.15	604	539	189	1212
AH 11	8286	27.94	14.82	700	538	122	1819
L29 X F6	8276	27.78	14.93	599	508	178	1302
L29 X A4	8250	27.25	15.13	597	530	118	1324
A1 X L33	8083	26.90	15.02	699	688	159	1218
HH22	8021	27.58	14.47	644	490	133	1549
F6 X A4	8007	24.78	16.16	625	596	134	1454
A4 X F4	7939	25.27	15.72	584	445	168	1657
F4 X L33	7929	25.55	15.52	611	513	240	1395
A1 X L29	7926	25.80	15.37	641	609	126	1315
L29 X L33	7881	25.80	15.28	683	662	157	1288
A5 X A1	7867	25.63	15.33	553	458	93	1418
A5 X L29	7646	25.24	15.14	680	569	143	1650
F6 X A1	7621	25.44	14.92	553	486	129	1151
A4 X L53	7606	23.95	15.89	760	820	108	1391
US22/3	7579	24.92	15.19	726	646	139	1604
AH10	7485	25.44	14.73	676	552	118	1596

Table 1-1 (continued). Yield sugar percentage and quality factors for hybrids and inbreds in a 9x9 diallel. Logan, Utah 1975

Description	Acre Yield Gross Sugar (Lbs)	Tons Beets	Percent Sugar	PPM Index	N	Na	K
F4 X A1	7482	24.48	15.32	610	531	160	1370
F4 X A5	7324	23.92	15.32	612	422	217	1735
F6 X L33	7289	23.65	15.36	531	450	146	1239
A5 X L33	7278	23.26	15.66	603	519	146	1496
E1 X F6	7225	22.41	16.11	646	628	96	1507
F4 X E1	7193	23.35	15.35	705	552	281	1690
A4 X A1	7069	23.51	15.05	642	582	120	1366
A5 X F6	7034	22.44	15.78	561	447	142	1532
L33 X E1	6937	22.06	15.68	746	776	170	1345
A4 X A5	6936	22.33	15.52	656	602	95	1534
L29	6706	23.29	14.39	743	617	175	1553
F6 X F4	6478	21.50	15.07	635	466	242	1614
L33 X A4	6340	20.08	15.78	548	480	86	1383
A5	5814	18.37	15.79	534	409	98	1589
F6	5653	18.45	15.28	630	538	139	1484
L33	4845	15.90	15.24	679	668	164	1254
A1	4844	16.42	14.74	773	784	93	1265
E1	4766	15.15	15.72	663	690	98	1271
A4	4450	14.52	15.24	508	450	69	1184
L53	4206	12.90	16.30	686	738	120	1353
F4	3939	13.61	14.43	769	583	200	1815
Mean of all entries	7438	24.23	15.35	654	583	150	1459
Standard Error	802	2.37	0.65	93	96	60	183
LSD (5% Point)	912	2.69	0.74	106	109	68	208
C.V. Percent	10.78	9.78	4.22	14.24	16.42	39.60	12.56
Calculated F	16.84**	20.73**	2.59**	3.54**	6.86**	3.68**	5.27**

Table 1-2. Diallel analysis and heterosis for gross sugar.

	CMS Female									Total	Hybrid	Heterosis
Male	L29	L33	L53	A1	A4	A5	E1	F4	F6	Mean	Mean	Mean
L29	6706	7881	8670	7926	8250	7646	8685	8633	8276	7938	8246	2486**
L33		4845	8407	8083	6340	7278	6937	7929	7289	6983	7518	2572**
L53			4206	8701	7606	8365	9362	9045	8312	7688	8559	3892**
A1				4844	7069	7867	8623	7482	7621	7306	7922	2976**
A4					4450	7324	8720	7939	8007	7015	7657	2884**
A5						5814	8517	7324	7034	7298	7669	2299**
E1							4766	7193	7225	7479	8157	3246**
F4								3939	6478	6990	7753	3203**
F6									5653	7155	7530	2231**

GCA F ratio = 9.39**
SCA F ratio = 19.49**
LSD 5% point for line (Total) means = 274
LSD 5% point for individual entry means = 912
LSD 5% point for hybrid means = 323

Table 1-3. Diallel analysis and heterosis for root yield.

	CMS Female									Total	Hybrid	Heterosis
Male	L29	L33	L53	A1	A4	A5	E1	F4	F6	Mean	Mean	Mean
L29	23.3	25.8	28.4	25.8	27.3	25.2	27.8	28.6	27.8	26.3	27.1	7.6**
L33		15.9	27.2	26.9	20.1	23.3	22.1	25.6	23.7	22.6	24.3	8.1**
L53			12.9	28.4	24.0	26.7	29.8	29.6	27.1	24.7	27.7	12.7**
A1				16.4	23.5	25.6	28.5	24.5	25.4	24.2	26.1	9.6**
A4					14.5	22.3	27.4	25.3	24.8	22.4	24.3	8.7**
A5						18.4	26.7	23.9	22.4	23.3	24.5	7.2**
E1							15.2	23.4	22.4	23.8	26.0	10.1**
F4								13.6	21.5	23.0	25.3	10.1**
F6									18.5	23.2	24.4	7.0**

GCA F ratio = 14.63**
SCA F ratio = 22.66**
LSD 5% point for line (Total) means = 0.81
LSD 5% point for individual entry means = 2.69
LSD 5% point for hybrid means = 0.95

Table 1-4. Diallel analysis and heterosis for sugar percentage.

	CMS Female											
Male	L29	L33	L53	A1	A4	A5	E1	F4	F6	Total Mean	Hybrid Mean	Heterosis Mean
L29	14.4	15.3	15.3	15.4	15.1	15.1	15.7	15.0	14.9	15.1	15.2	0.35*
L33		15.2	15.4	15.0	15.8	15.7	15.7	15.5	15.4	15.4	15.5	0.23*
L53			16.3	15.3	15.9	15.7	15.7	15.2	15.3	15.6	15.5	0.22
A1				14.7	15.1	15.3	15.2	15.3	14.9	15.1	15.2	0.16
A4					15.2	15.5	15.9	15.7	16.2	15.6	15.7	0.41*
A5						15.8	16.0	-15.3	15.8	15.6	15.6	0.08
E1							15.7	15.4	16.1	15.7	15.7	0.25*
F4								14.4	15.1	15.1	15.3	0.44*
F6									15.3	15.4	15.5	0.19

GCA F ratio = 10.6**
SCA F Ratio = 0.67
LSD 5% point for line (Total) means =0.22
LSD 5% point for individual entry means =0.74
LSD 5% point for hybrid means =0.26

* 5% point; ** 1% point significance

Table 1-5. Diallel analysis and heterosis for impurity index.

	CMS Female											
Male	L29	L33	L53	A1	A4	A5	E1	F4	F6	Total Mean	Hybrid Mean	Heterosis Mean
L29	743	683	688	641	597	680	602	611	599	659	638	-61**
L33		679	627	699	548	603	746	611	531	641	631	-40*
L53			686	720	760	748	717	782	755	717	725	51*
A1				773	642	553	761	610	553	673	647	-65**
A4					508	656	635	584	625	606	631	35*
A5						534	606	612	561	609	627	38*
E1							663	705	646	674	677	13
F4								769	635	669	644	-66**
F6									630	617	613	37*

GCA F ratio = 3.49**
SCA F ratio = 2.71**
LSC 5% point for line (Total) means = 32
LSD 5% point for individual entry means = 106
LSD 5% point for hybrid means = 34

* 5% point; ** 1% point significance

Table 1-6. Diallel analysis and heterosis for PPM nitrogen.

	CMS Female									Total	Hybrid	Heterosis
Male	L29	L33	L53	A1	A4	A5	E1	F4	F6	Mean	Mean	Mean
L29	617	662	639	609	530	569	540	462	508	575	565	-47*
L33		668	585	688	480	519	776	513	450	601	584	-51*
L53			738	719	840	673	675	651	716	697	687	22
A1				284	582	458	735	531	486	638	601	-84**
A4					450	602	597	445	596	557	584	45*
A5						409	485	422	447	499	522	1
E1							690	552	628	637	624	-20
F4								583	466	521	504	-93**
F6									538	537	537	-41*

GCA F ratio = 24.5**
SCA F ratio = 4.0**
LSD 5% point for line (Total) means = 33
LSD 5% point for individual entry means = 109
LSD 5% point for hybrid means = 38

* 5% point; ** 1% point significance

Table 1-7. Diallel analysis and heterosis for PPM sodium.

	CMS Female									Total	Hybrid	Heterosis
Male	L29	L33	L53	A1	A4	A5	E1	F4	F6	Mean	Mean	Mean
L29	175	157	149	126	118	143	126	172	178	134	146	-3
L33		164	188	159	86	146	170	240	146	162	161	17
L53			120	134	108	180	160	292	206	166	177	52*
A1				93	120	93	120	160	129	123	130	17
A4					69	95	133	168	134	110	120	17
A5						98	160	217	142	137	147	32*
E1							98	281	96	144	156	41*
F4								200	242	217	221	61**
F6									139	155	159	26*

GCA F ratio = 4.54**
SCA F ratio = 3.98**
LSD 5% point for line (Total) means = 20.3
LSD 5% point for individual entry means = 68
LSD 5% point for hybrid means = 24

* 5% point; ** 1% point significance

Table 1-8. Diallel analysis and heterosis for PPM potassium.

	CMS Female									Total	Hybrid	Heterosi
Male	L29	L33	L53	A1	A4	A5	E1	F4	F6	Mean	Mean	Mean
L29	1614	1288	1427	1315	1324	1650	1429	1562	1302	1452	1412	-96*
L33		1254	1256	1218	1383	1496	1345	1395	1239	1313	1327	-23
L53			1352	1307	1391	1743	1553	1722	1414	1452	1477	84*
A1				1265	1366	1418	1446	1370	1151	1312	1324	-31
A4					1184	1535	1467	1657	1454	1395	1447	127*
A5						1589	1686	1735	1532	1597	1599	102*
E1							1271	1690	1507	1467	1515	157**
F4								1815	1614	1638	1593	-3
F6									1484	1418	1402	-49

GCA F ratio = 20.13**
SCA F ratio = 1.68**
LSD 5% point for line (Total) means = 63
LSD 5% point for individual entry means = 208
LSD 5% point for hybrid means = 73

* 5% point; ** 1% point significance

Table 3. Root yield, sugar percentage and impurity factors for new hybrids. Farmington, Utah - 1975

Description	Acre Yield		Percent Sugar	PPM			
	Gross Sugar (lbs)	Tons Beets		Index	N	Na	K
GWD2	9102	27.47	16.57	525	448	87	1566
USH20	8455	27.17	15.58	491	345	216	1359
L53XC13	8398	26.34	16.02	551	402	180	1661
A4X73708	8320	24.94	16.69	423	328	134	1326
C1 X P3	8180	25.55	16.03	554	405	180	1657
L53X908A	8151	25.08	16.28	585	460	236	1617
AH10	8099	25.38	15.92	432	295	111	1404
L33XC13	8078	25.77	15.72	529	364	169	1625
L53X1512	8053	23.76	17.00	507	407	182	1564
HH22	7949	25.91	15.37	457	298	103	1473
U1 X 5	7806	23.79	16.44	464	337	164	1475
L33X73708	7683	23.38	16.44	537	381	205	1705
U1 X 4	7574	22.69	16.63	460	386	123	1330
USH10B	7555	24.56	15.38	508	328	120	1633
L33XP3	7537	22.33	16.87	397	272	127	1414
L53XP3	7428	23.18	16.04	594	453	148	1720
AH11	7223	22.91	15.77	511	303	184	1743
U1 X 1	7173	22.03	16.32	504	412	162	1399
U1 X 2	7139	22.22	16.01	454	330	216	1273
U1 8	7101	22.94	15.49	554	443	201	1385
A4XC13	6994	21.72	16.11	544	375	138	1804

Table 3 continued.

Description	Acre Yield Gross Sugar (lbs)	Acre Yield Tons Beets	Percent Sugar	PPM Index	PPM N	PPM Na	PPM K
A4XP3	6917	19.99	17.32	407	298	108	1471
L53X73708	6893	20.84	16.55	441	336	93	1433
A5X73708	6890	20.60	16.72	466	377	97	1471
L33X0506-7	6861	20.84	16.48	414	311	155	1273
UI X 3	6736	20.71	16.25	479	367	179	1387
L33X73702	6659	20.13	16.53	425	355	158	1168
A5XP3	6631	19.94	16.58	425	280	144	1503
L53X73702	6615	19.80	16.71	533	453	130	1536
US22/3	6439	19.36	16.71	530	414	203	1596
A5X73702	6287	18.98	16.55	443	305	152	1494
F4X73708	6203	19.08	16.18	490	352	127	1566
L53X0506-7	5977	18.32	16.32	499	404	177	1383
F6XP3	5896	17.27	17.15	450	335	120	1568
L33X908A	5784	17.57	16.42	551	436	196	1581
L53X0507-3	5765	17.22	16.78	503	434	153	1423
L33X1512	5218	15.51	16.82	499	409	166	1473
A4X0506-7	5195	15.43	16.88	430	316	128	1461
A5X0506-7	4439	13.72	16.21	477	310	168	1604
Mean of all entries	7062	21.65	16.35	489	366	155	1501
Standard error	902	2.72	0.63	84	87	54	180
LSD (5% point)	1026	3.09	0.72	95	99	61	205
C.V. Percent	12.77	12.56	3.87	17.09	23.70	34.60	12.00
Calculated F	7.71**	9.40**	3.35**	2.27**	2.39**	2.89**	3.70**

Table 4. Root yield, sugar percent, and quality factors for nine commercial hybrids, US22/3, and 16 experimental hybrids at Logan, Utah - 1975.

Description	Acre Yield		Percent Sugar	PPM			
	Gross Sugar (lbs)	Tons Beets		Index	N	Na	K
GWD2	8659	27.88	15.57	576	498	48	1518
[(L33XL29)XL5] X L37	8615	26.98	15.98	629	622	52	1446
(L33XL5) X L19	8425	23.57	17.90	387	356	53	1267
UI 7	8131	24.45	16.33	448	446	57	1106
(L12XC1) X L37	8044	24.67	16.30	638	650	54	1469
(C1XL53) X (E1X629Rf)	8009	24.64	16.26	539	519	58	1340
UI X 5	7987	24.20	16.51	405	393	85	978
A7113 X L39	7848	22.91	17.13	505	512	84	1294
AH11	7818	24.75	15.84	537	439	59	1549
L53 X L38	7807	25.19	15.48	716	598	129	1832
AH10	7791	24.86	15.66	493	387	53	1463
(L29XL21) X L19	7709	22.36	17.24	472	475	68	1252
USH20	7566	23.84	15.88	516	472	92	1265
UI X 4	7467	22.91	16.30	487	492	73	1090
USH10B	7380	24.83	14.85	623	476	99	1627
AH4	7333	22.28	16.46	444	379	72	1307
HH22	7322	23.95	15.14	556	427	66	1530
[(L33XL29)XL5] X L19	7317	21.20	17.22	475	383	107	1574
UI X 3	6933	22.96	15.17	564	472	114	1355
US22/3	6917	22.06	15.71	627	576	93	1465
UI X 2	6786	22.25	15.38	592	544	86	1317

Table 4 continued.

Description	Acre Yield Gross Sugar (lbs)	Tons Beets	Percent Sugar	PPM Index	N	Na	K
(L33XC1) X 29.008	6739	21.56	15.67	688	679	120	1406
UI 8	6735	22.16	15.20	541	486	91	1208
UI X 1	6712	21.06	15.93	569	534	112	1300
OV X L10	6587	21.81	15.07	684	561	126	1659
(L33XL29) X A7134	6449	19.39	16.62	555	660	53	969
Mean of all varieties	7503	23.41	16.04	549	502	82	1369
Standard Error	830	2.56	0.72	87	85	34	178
LSD (5% point)	949	2.92	0.83	100	97	38	204
C.V. Percent	11.06	10.93	4.50	15.92	16.96	40.74	13.01
Calculated F	3.51**	3.20**	6.83**	5.77**	6.83**	3.41**	8.02**

Table 5. Root yield, sugar percent, and quality factors for nine commercial hybrids, US22/3, and 16 experimental hybrids at Farmington, Utah - 1975

Description	Acre Yield Gross Sugar (lbs)	Acre Yield Tons Beets	Percent Sugar	PPM Index	PPM N	PPM Na	PPM K
GWD2	9557	29.32	16.27	507	430	85	1469
HH22	9220	28.68	16.08	460	326	112	1488
(L12XC1) X L37	9198	28.27	16.28	625	599	127	1486
USH20	8862	27.14	16.33	446	325	199	1321
(L33XL5) X L19	8696	24.80	17.52	467	406	174	1397
A7113 X L39	8543	24.26	17.62	550	570	158	1355
[(L33XL29)XL5] X L37	8533	25.55	16.71	555	518	98	1490
(CLXL53) X (E1X629Rf)	8481	24.80	17.11	398	304	132	1321
UI 7	8451	25.52	16.54	400	324	144	1146
UI X 4	8176	24.26	16.86	441	368	160	1271
[(L33XL29)XL5] X L19	8029	22.25	18.04	389	310	139	1372
AH11	7918	24.14	16.40	467	325	145	1558
USH10B	7910	25.05	15.84	499	325	136	1640
AH10	7896	25.30	15.62	463	342	126	1334
AH4	7858	23.87	16.48	439	324	169	1355
L53 X 38	7735	24.31	15.95	643	507	172	1832
(L29XL21) X L19	7590	20.84	18.22	430	389	138	1376
UI X 5	7355	22.55	16.30	434	365	129	1178
OV X L10	7341	24.48	15.00	638	492	298	1431
(L33XL29) X A7134	7121	21.01	16.93	446	456	124	1022
UI X 3	7111	21.81	16.31	505	411	185	1380

Table 5 continued.

Description	Acre Yield Gross Sugar (lbs)	Acre Yield Tons Beets	Percent Sugar	PPM Index	PPM N	PPM Na	PPM K
UI X 2	7010	22.06	15.83	497	390	209	1277
UI 8	6973	21.56	16.17	460	372	179	1229
UI X 1	6809	21.64	15.74	495	387	167	1290
(L33XC1) X 29.008	6593	20.76	15.88	496	422	236	1132
US22/3	6294	19.96	15.80	471	313	172	1477
Mean of all varieties	7895	24.01	16.46	486	397	159	1371
Standard Error	798	2.18	0.80	73	91	49	148
LSD (5% point)	912	2.49	0.91	83	104	55	170
C.V. Percent	10.12	9.09	4.84	14.95	23.01	30.58	10.83
Calculated F	7.07**	7.99**	5.48**	5.36**	4.96**	5.01**	7.67**

Table 6. Root yield, sugar percentage, and quality factors for inbreds tested at Logan, Utah - 1975.

Description	Acre Yield		Percent Sugar	PPM			
	Gross Sugar (lbs)	Tons Beets		Index	N	Na	K
FC506	8301	26.48	15.68	538	462	130	1340
L9	8053	24.50	16.44	571	584	107	1261
C13	7602	27.02	14.06	809	616	84	1967
L21	7097	22.44	15.80	505	444	100	1268
L52	6892	23.10	14.94	550	444	137	1302
00.5	6250	22.15	14.14	693	478	216	1701
L19	6212	17.12	18.24	378	425	42	996
74517	6201	20.05	15.46	773	838	62	1337
L54	5870	19.14	15.36	568	439	140	1533
9602	5777	19.43	14.95	604	464	174	1514
A1-1	5562	18.85	14.78	681	692	98	1119
908A	5558	17.90	15.53	492	443	95	1151
L6	5436	17.57	15.48	519	528	96	958
8513	5383	17.57	15.41	588	512	152	1353
74519	5377	16.00	16.79	474	469	98	1176
L8	5176	15.96	16.19	542	542	40	1277
L89	5174	16.34	15.86	731	856	66	1097
L39	5101	16.09	15.84	515	505	117	1068
L38	5095	17.90	14.26	754	576	180	1707
L37	4860	15.96	15.25	940	996	83	1619
L20	4740	15.84	14.94	530	543	81	882

Table 6 continued.

Description	Acre Yield Gross Sugar (lbs)	Acre Yield Tons Beets	Percent Sugar	PPM Index	PPM N	PPM Na	PPM K
L29	4649	15.68	14.89	545	499	79	1135
74518	4477	14.02	16.04	636	629	76	1451
74515	4331	13.12	16.49	434	407	73	1129
L33	4267	13.74	15.54	698	758	129	1132
A1-10	4234	13.49	15.70	507	448	61	1302
L10	4202	13.24	15.85	589	625	81	1113
74514	4063	12.99	15.64	746	805	71	1353
L53	3652	10.97	16.66	631	717	117	1170
FC504	2499	9.24	13.50	835	606	204	1771
L18	2450	8.13	15.08	916	1090	87	1037
LRf-1	1709	6.39	13.14	699	463	102	1616
Mean of all varieties	5195	16.83	15.43	627	591	106	1308
Standard Error	832	2.77	0.62	72	79	38	130
LSD (5% point)	1171	3.90	0.87	102	112	53	183
C.V. Percent	16.02	16.47	4.01	11.53	13.42	35.53	9.93
Calculated F	12.99**	12.38**	10.33**	14.09**	18.96**	5.28**	15.93**

Table 7-1. Root yield, sugar percentage and quality factors for hybrids and inbreds in powdery mildew experiment at Farmington, Utah - 1974

Description	Acre Yield		Percent	PPM			
	Gross Sugar (lbs)	Tons Beets	Sugar	Index	N	Na	K
L53 X L37	9746	29.73	16.36	667	608	148	1711
L29 X L37	9453	29.29	16.15	607	521	122	1661
L53 X L35	8897	27.34	16.28	477	347	137	1511
L53 X A7135	8894	28.49	15.61	571	457	158	1511
L53 X L19	8791	24.64	17.88	528	505	134	1555
L29 X L53	8587	26.46	16.25	499	376	160	1501
A7112 X L37	8454	25.36	16.68	533	493	109	1429
L29 X L19	8337	23.60	17.63	447	355	138	1536
A4 X L19	8104	22.00	18.40	436	402	87	1469
Susc. check	8008	23.54	17.02	441	374	152	1290
A4 X L37	7996	24.97	16.02	649	606	132	1532
A7112 X L19	7912	22.30	17.76	444	362	162	1473
L29 X A7135	7826	23.70	16.50	512	396	159	1560
A7112 X L35	7616	22.63	16.73	382	279	107	1269
A4 X L53	6169	18.54	16.54	585	603	88	1340
A4 X L35	5988	18.42	16.25	507	401	104	1547
L29 X L35	5881	17.60	16.63	470	367	71	1543
US33	5818	17.57	16.55	549	408	176	1752
A4	5301	16.06	16.60	393	280	106	1326
A7135	5241	16.44	15.97	427	358	114	1125
L37	4961	16.61	15.03	903	812	171	1903

Table 7-1 continued.

Description	Acre Yield		Percent	PPM			
	Gross Sugar (lbs)	Tons Beets	Sugar	Index	N	Na	K
L19	4879	12.70	19.15	466	475	88	1536
A7112	4542	13.75	16.58	452	347	167	1357
L35	3738	11.69	16.02	484	396	126	1336
L29	3479	11.80	14.85	568	407	155	1518
L53	2885	8.69	16.60	492	506	124	1079
Mean of all entries	6827	20.54	16.62	519	441	131	1476
Standard error	971	2.82	0.75	85	100	41	159
LSD (5% point)	1110	3.22	0.85	98	114	47	182
C.V. Percent	14.22	13.74	4.49	16.4	22.6	31.1	10.8
Calculated F	25.39**	26.66**	9.53**	9.42**	8.51**	3.16**	7.81**

Table 7-2. Mean squares and calculated F values of male and female parents for powdery mildew readings at Farmington, Utah, 1975.

	af	Mean Squares	F
Males	4	26.086	91.43**
Females	3	2.380	8.33**
Males X Females	12	1.906	6.68**
Error	125	0.285	

Table 7-3. Means of powdery mildew readings for inbreds and hybrids evaluated at Farmington, Utah, 1975.

Female Parents	L35	L19	L37	L53	A7135	Hybrid Mean	Female Parent
L29	3.83	3.83	1.17	3.67	3.17	2.61	3.67
L53	3.50	4.00	1.35	2.83	3.00	2.44	2.83
A4	3.17	4.33	1.33	2.50	(3.00)*	(2.39)	3.00
A7112	4.67	4.00	1.67	(3.53)*	(3.59)*	(2.91)	5.00
Hybrid Mean	3.79	4.04	1.37	3.13	3.19		
Inbred Parent	3.67	3.00	1.17	2.83	2.00		

LSD for inbred parents = .61

LSD for hybrid means summed over males = .27

LSD for hybrid means summed over females = .30

* Estimated values for hybrids not included in the experiment.

Table 7-4. Estimates of heterosis for powdery mildew resistance at Farmington, Utah - 1975.

	Mean of Hybrids	Mean of Inbred Parents	Heterosis
L29	2.612	3.102	0.490*
L53	2.866	2.818	-0.048
A4	2.833	2.834	0.001
A7112	3.447	3.807	0.360*
L35	3.79	3.648	-0.142
L19	4.04	3.313	-0.727**
L37	1.37	2.398	1.028**
A7135	3.085	2.625	-0.460

* Significant at the 5% point.

** Significant at the 1% point.

GENOTYPE TIMES NITROGEN TIMES WATER INTERACTION

D. L. Doney, D. W. James, and J. C. Theurer

This is the third report of a cooperative study to evaluate genotype times environment interactions. Experiments the past two years have been concerned with the effect of nitrogen on genotypes that differ in yield and sugar potential. Significant genotype times nitrogen interactions were observed for both yield and quality, indicating that certain genotypes are affected more by nitrogen than others.

This year's study involved the environmental effect of water and nitrogen on genotype. Eight hybrids known to differ in their yield and sugar concentration potential were selected for this test. The experimental design was a split-split (unbalanced)-plot design replicated three times. Water levels (4) were whole plots with fertilizer levels (5) as sub-plots and genotypes (8) as sub-sub-plot. The eight genotypes, five nitrogen rates, and four water rates are given in Table 1. The test was planted May 2 and thinned June 3. The nitrogen rates were applied and water treatments begun immediately after thinning. Roots were harvested, weighed October 21, and analyzed for percent sugar and impurity index.

Results

In order to minimize the total number of treatments, nitrogen rates were unequally distributed within water treatments. This resulted in a confounding of the nitrogen treatments and a rather complicated analysis of variance. However, sources of variation due to water rate, nitrogen rate, genotype, and genotype times nitrogen within water could be tested (Table 2). The interactions of genotype times water and nitrogen could not be tested. The F ratios in the analysis of variance table for root yield, percent sugar, gross sugar, and the impurity index are given in Table 2. The different water rates significantly affected root yield, gross sugar, and the impurity index but had no effect on percent sugar (Table 2). There were significant effects due to nitrogen rate on all four characters (Table 2). The genotypes differed significantly for each of the four characters (Table 2). There was no significant genotype times nitrogen within water interaction for any of the measured characters (Table 2). However, as mentioned earlier, the important interactions could not be tested. A careful examination of the individual genotypic means suggests interactions do exist even though we cannot test these interactions statistically.

The mean root yield, percent sugar, gross sugar, and impurity index for each of the genotypes at each nitrogen and water rate are given in Tables 3, 4, 5, and 6. Hybrid L53 X A7135 responded mostly

to high nitrogen and high water rates (Table 3); whereas, hybrids A7112 X L37 and USH20 yielded well under low nitrogen and did not respond much to the high nitrogen rates (Table 3). USH20 was very uniform in yield over all but the zero nitrogen rate. This hybrid was also uniform in percent sugar over the nitrogen rates, being affected adversely at only the very high nitrogen rate (Table 4). However, at the 270 pounds of N per acre, an adverse effect was beginning to show up in USH20 as indicated by the impurity index. Gross sugar for USH20 did not change significantly when rates of nitrogen were increased over 90 pounds per acre; whereas, all other genotypes showed significantly more gross sugar with increased nitrogen rates (Table 5).

L53 X A7135 and USH20 were contrasting genotypes in reaction to increased levels of nitrogen. Hybrid A7112 X L37 reacted similarly to USH20, while the other genotypes' reaction was somewhat between that of USH20 and L53 X A7135 (Tables 3, 4, 5, and 6). Most genotypes reacted in a similar manner when water rates were increased; i.e., the higher water rates increased root yield, gross sugar, and impurity index (Tables 3, 5, and 6). Increased water rates had little effect on percent sugar for the genotypes.

There appears to be a nitrogen times genotype interaction for root yield, percent sugar, gross sugar, and impurity index but little, if any, water times genotype interaction for the same factors (Tables 3, 4, 5, and 6). Percent sugar is affected very little by different water rates (Table 4).

Table 1. Treatments: genotypes, nitrogen rates, and water rates.

Treatment Number	Genotypes	Nitrogen Rates Lbs/Acre	Water Rates Irrigate When
1	A7112 X L19	0	10 atm
2	HH22	90	5 atm
3	TASCO AH11	180	1 atm
4	U&I Hy 8	270	0.3 atm
5	USH20	360	
6	A7112 X L37		
7	Ov1 X L39		
8	L53 X A7135		

Table 2. Analysis of variance and F ratios for root yield, percent sugar, gross sugar, and the impurity index.

Source of Variation	df	Yield	Percent Sugar	Gross Sugar	Impurity Index
Reps	2				
Water	3	23.49**	1.33^{ns}	20.93**	39.94**
Error (a)	6				
N/Water	2	75.42**	11.26**	70.11**	46.90**
Error (b)	16				
Genotypes	7	17.61**	33.38**	11.69**	16.81**
Genotype x N/water	77	0.84^{ns}	0.80^{ns}	0.69^{ns}	1.25^{ns}
Error (c)	168				
Total	287				

Table 3. Mean root yield for the eight genotypes at each nitrogen and water rate.

	Nitrogen Rates (Lbs/Acre)					Water Rates			
Genotype	0	90	180	270	360	1	2	3	4
A7112 X L19	8.1	15.1	16.0	16.8	21.1	11.2	13.7	17.8	19.1
HH22	7.0	16.2	19.1	19.0	22.4	12.7	14.8	20.0	21.0
TASCO AH11	8.9	17.6	19.1	22.4	26.2	14.2	15.1	22.2	24.1
UI Hy 8	6.6	16.2	17.5	19.0	21.8	12.5	14.4	18.4	20.5
USH20	9.7	21.4	22.7	23.8	24.4	16.7	17.8	24.1	24.5
A7112 X L37	8.4	17.8	23.3	24.7	24.9	15.8	18.4	23.0	24.4
Ovl X L39	8.3	14.8	19.4	19.4	22.5	13.0	15.7	19.9	20.7
L53 X A7135	9.2	17.5	21.7	22.8	28.4	14.8	17.3	22.9	25.8
LSD =	2.4					6.8			
Mean =	8.1	17.1	19.7	21.0	24.0	13.7	15.8	21.0	22.5

Table 4. Mean percent sugar for the eight genotypes at each nitrogen and water rate.

Genotype	Nitrogen Rates (Lbs/Acre) 0	90	180	270	360	Water Rates 1	2	3	4
A7112 X L19	18.0	19.1	18.3	17.7	17.4	18.5	17.9	18.3	17.9
HH22	15.2	16.9	16.1	15.3	14.5	15.8	15.5	16.1	15.3
TASCO AH11	15.8	16.6	15.9	15.2	14.9	15.9	15.4	15.9	15.5
UI Hy 8	16.2	17.0	16.3	16.4	15.2	15.9	16.4	16.3	16.2
USH20	16.0	16.7	16.3	16.1	15.4	15.9	16.2	16.3	16.1
A7112 X L37	17.4	17.1	17.0	15.8	16.0	17.0	16.8	17.2	16.0
Ov1 X L39	15.7	16.7	16.5	15.7	15.2	16.2	15.8	16.2	16.0
L53 X A7135	15.7	17.0	15.8	15.7	15.0	15.8	15.7	16.0	15.7
LSD =	0.9					1.4			
Mean =	16.3	17.1	16.5	16.0	15.4	16.4	16.2	16.6	16.1

Table 5. Mean gross sugar for the eight genotypes at each nitrogen and water rate.

Genotype	Nitrogen Rates (Lbs/Acre) 0	90	180	270	360	Water Rates 1	2	3	4
A7112 X L19	2913	5752	5852	5908	7338	4151	4903	6484	6870
HH22	2139	5472	6155	5788	6512	4061	4615	6410	6394
TASCO AH11	2812	5839	6094	6803	7812	4535	4582	7049	7470
UI Hy 8	2143	5496	5708	6234	6441	3973	4728	5959	6627
USH20	3080	7118	7379	7684	7520	5314	5760	7858	7843
A7112 X L37	2939	6146	7927	7875	7974	5371	6150	7856	7817
Ov1 X L39	2607	4984	6378	6075	6819	4210	4957	6395	6599
L53 X A7135	2874	5964	6869	7142	8517	4705	5424	7263	8097
LSD =	754					2322			
Mean =	2796	5846	6510	6688	7392	4513	5193	6909	7215

Table 6. Mean impurity index for the eight genotypes at each nitrogen and water rate.

Genotype	Nitrogen Rates (Lbs/Acre)					Water Rates			
	0	90	180	270	360	1	2	3	4
A7112 X L19	331	284	388	464	552	338	382	416	468
HH22	361	383	396	587	745	389	479	468	577
TASCO AH11	410	371	498	615	756	476	491	513	618
UI Hy 8	362	355	382	524	621	362	422	423	544
USH20	338	367	392	537	601	370	433	413	534
A7112 X L37	362	406	555	641	778	443	547	580	628
Ovi X L39	399	362	462	643	751	430	495	509	619
L53 X A7135	381	394	512	662	767	407	498	580	668
LSD =	85					94			
Mean =	361	366	450	584	698	402	467	489	582

GENOTYPIC COMPETITION IN SELECTION

Devon L. Doney

In commercial plantings of sugarbeets, strong competition is exerted between neighboring plants. Most commercial hybrids are fairly uniform genetically. Therefore, this strong competition is largely environmental. However, selection must be practiced in heterozygous populations that exhibit varying degrees of genotypic competition. Some plant breeders have gone to space-planted populations for selection purposes. This eliminates the confounding effects of genotypic competition.

Four years ago we initiated a program to measure the different competition parameters and to evaluate their importance and effect on selection.

Previously reported data indicate that: 1) Genotypic competitive ability (the ability of a plant to respond to competition of a common competitor) is of primary importance in selection. This parameter seemed to be the predominate competitive factor in heterozygous populations. Considerable variation for this character existed in sugarbeet; 2) Genotypic competitive influence (the effect of a given genotype on its common competitor) is not as strong as competitive ability, but significant variation is present in some populations; 3) Certain genotypic combinations compliment each other; i.e. they yield more when grown together than the mean yield of each grown separately. This would indicate the presence of both competitive ability and competitive influence.

Previous tests have been conducted in the field. This past year an additional test was conducted in the greenhouse.

This test was designed to measure the competition effects in seedlings. Seed was planted in 5cm, 3cm, and 1cm paper pots. All pots received an equal amount of nutrient solution daily. Plants were harvested and weighed 60 days after planting. Planting was arranged so that the following variance component models apply:

Common competitor(pure stand) = $Ve+Vec$,
Common competitor (mixed stand) = $Ve+Vec+Vgl$,
Heterozygous population (pure stand) = $Ve+Vec+Vg+VglA$,
Heterozygous population(mixed stand) = $Ve+Vec+Vg+VgA$.

Where:
- Ve = environmental variance,
- Vec = environmental competition variance,
- Vgl = genotypic competition influence variance
- Vg = genotypic variance
- VgA = genotypic competition ability variance
- $VglA$ = genotypic competition interaction between influence and ability

From the above variances, estimates of the competitive ability and competitive influence variance could be obtained. Two heterozygous lines were tested.

As was expected, the relative environmental competition increased with increased competition (Table 1). Significant competitive ability and competitive influences were present in both lines (Table 1). However, there seemed to be an inverse relationship; i.e. the larger the competitive influence variance, the smaller the competitive ability variance (Table 1). The largest competitive influence occurred at the 3cm-size pot in both lines.

In order to test the importance of these parameters in selection, selections were made for different combinations of their effect in a competition field trial in 1973. Selfed seed from these selections was planted to a replicated field trial in 1975. A number of the selections produced insufficient seed for testing; however, there was sufficient seed of five paired combinations to adequately field test. All selections tested were selected for positive competitive ability (Table 2). Each pair differed in competitive influence (Table 2). A positive competitive influence indicates the selection exerted a positive influence on its neighbor, causing it to yield significantly greater than its mean. A zero competitive influence means the neighboring competitor yielded the same as its mean, and a negative competitive influence means the selections influence caused the neighboring competitor to yield significantly less than its mean. In all comparisons, the more positive the competitive influence, the greater the yield (Table 2). Percent sugar seemed to be affected very little (Table 2). It appears that both competitive ability and competitive influence are important selection parameters. In a competition experiment, it is difficult to find genotypes that exhibit a positive effect for both parameters. However, it appears that the breeder should be looking for these genotypes.

Table 1 - Estimated variances for competitive influence, competitive ability, and environmental competition for two heterozygous lines.

Heterozygous Line	Pot Size	Competitive Influence Variance	Competitive Ability Variance	Relative Environmental Competition Variance
AD937	5cm	4.5	44.0**	
	3cm	7.2*	0.0	5
	1cm	1.2	4.8*	33
AN505	5cm	1.8*	2.2*	0
	3cm	3.1*	-9.6*	2
	1cm	1.9*	1.9*	2

* = Significant at p = .05

** = Significant at p = .01

Table 2. Root yield and percent sugar for five selection pairs selected for different combinations of competitive ability and influence.

Code	Selected for: Competitive Ability	Selected for: Competitive Influence	Root Yield Tons/Acre	% Sugar	Notes
d92	+	+	20.35*	15.08	
d93	+	-	8.97	14.64	Poor Stand
d94	+	+	18.70*	15.59	
d95	+	-	15.90	15.66	
d97	+	+	16.34	14.57	
d96	+	0	15.81	16.13	
d100	+	0	15.46*	16.38	
d99	+	-	10.18	15.64	
d111	+	+	15.12*	15.84*	
d112	+	-	11.52	14.91	

* = Significantly greater than paired selection.

BREEDING FOR SUGARBEET ROOT MAGGOT RESISTANCE

Carl C. Blickenstaff, J. C. Theurer, and Devon L. Doney

Sugarbeet root maggot is a major pest in many of the sugarbeet growing areas of the mountain states. Each year this insect is spreading to more and more fields. In 1974, we initiated a resistance breeding program at Kimberly, Idaho. The 1974 test consisted of a series of different lines from different genetic sources. A wide range of infection and damage existed in this material, suggesting that some natural resistance was present and could possibly be improved through an appropriate breeding program.

The 1975 tests were more elaborate with the following two goals in mind: 1) to gain an estimate of the genetic variability available for root maggot resistance and 2) to initiate a recurrent selection breeding program.

Two broadbase synthetics (one from the Logan Station and one from the Amalgamated Sugar Company) were planted to a replicated field test. Two genetically uniform lines were randomized within the test to obtain an estimate of the environmental variance.

An additional test which included some previously tested lines was conducted to determine the repeatability and accuracy of these measurements.

The technique for evaluating resistance to the sugarbeet root maggot was as follows:

Seeds were planted in paper pots (3 cm x 13 cm) in the greenhouse on March 27, using a commercial potting soil (Bacto Soil^{R}). Plants were transplanted to the field (pot and all) May 13-15. Row spacing was 22 inches with plants 1 foot apart in the row. Plots were furrow-irrigated. For the inbred lines test, plots were single rows containing 10 plants. Entries were randomized within each of six replicates. For the recurrent selection test, each replicate was eight plants long and two rows wide and contained two plants of each of two check entries and six plants of each of two broadbased lines. There were 40 replicates.

Natural fly population was augmented by release of about 60,000 flies in the test area.

Damage was assessed in mid-July by digging all plants and rating them individually on a damage scale of 0 = no damage to 5 = severe damage. At the time of digging, leaf length (crown to tip of longest leaf), and percentage of plants infested by the sugarbeet leaf miner were also determined.

The two broadbase synthetics were significantly different in root maggot damage (Table 1). There was a small correlation (0.38) of root maggot damage and leaf length. An adjustment for leaf length based on the regression line changed the mean difference to non-significant (Table 1). The important statistic in this test is the variance estimates. Both broadbase synthetics had larger variances than the inbred but were smaller than the uniform hybrid (Table 1). It is difficult to understand the large variance obtained for the uniform hybrid (#1166). There is some indication of the presence of a genetic variance, but it was non-significant in this test. High and low selections were made in this test for maggot resistance. Seed will be obtained from these selections this winter and will be evaluated next summer to determine if any progress has been achieved toward improved maggot resistance.

Some of the lines in the inbred test were entered twice in addition to having been tested in 1974. Most of the readings for duplicate lines were similar; however, for line L28, they were significantly different (Table 2). A significant correlation (0.50) between root maggot damage and leaf length also was observed in this material. Differences between lines were still present after adjustment for leaf length (Table 2). Generally the readings between the 1974 and 1975 lines were consistent, especially the lowest and highest lines (Table 2). However, there was enough inconsistency to render a correlation coefficient of only 0.49. The more replications the better the consistency and reliability, and the six replicate limitations we had this year may account for some of the inconsistency.

There were some difficulties in obtaining good infection and good stands that may account for some of the less favorable readings. We are continuing to improve the techniques to obtain more reliable data and plan to continue this cooperative project in 1976.

TABLE 1. Root maggot damage and leaf length means and variances for 2 broadbase synthetics, a uniform hybrid and inbred.

Line	Root Maggot Mean	Maggot Adjusted for Leaf Length	Leaf Length Mean	Root Maggot Variance	Leaf Length Variance
25A1 (Broadbase)	1.258b*	1.40a	9.359d	0.634	4.581
TASCO (Broadbase)	1.529a	1.44a	13.013a	0.716	4.754
1166	1.486ab	1.55a	10.513c	1.008	4.402
L19	1.365ab	1.39a	11.301b	0.441	4.192

1975 VARIETY TEST CORRELATIONS

r (root maggot X leaf length) = .50**

r (root maggot X % leaf miner) = .59**

r (% leaf miner X leaf length) = .59**

*Entries with different letter suffixes were significantly different at the 5% level.

TABLE 2. 1974 and 1975 root maggot damage readings for all lines that were tested both years.

ROOT MAGGOT TEST (1975-74 Comparison)

Line	Reps	1975 Root Maggot Reading	1975 SBRM Mean	1975 SBRM Adjusted for Leaf Length	1974 SBRM Reading
L19	6	1.013	1.192ab	1.329ab	2.3
	5	1.370			
L28	2	0.755b	1.300ab	1.409ab	11.1
	3	1.840a			
L29	3	1.057	1.062ab	1.159b	0.6
	4	1.067			
L35	4	0.625	0.786b	1.119b	0.6
	3	0.947			
L37	5	1.150	1.317ab	1.669a	9.9
	5	1.484			
961RF	3	1.167	1.104ab	1.209ab	2.6
	2	1.040			
L53	2	1.275	0.998ab	1.439ab	5.0
	3	0.720			
UI 8	5	1.232	1.230ab	1.419ab	1.6
	5	1.228			
AL039	6	1.638a	1.402a	1.359ab	15.6
	6	1.532ab			
	5	1.038b			
4607	4	1.380	1.380ab	1.539ab	0.3
SLC132	4	1.030	1.030ab	1.169ab	4.3
EL39	5	1.230	1.230ab	1.229ab	0.8

r(1975 SBRM X 1974 SBRM) = .49

r(1975 SBRM adj. for leaf length X 1974 SBRM) = .40

EVALUATION OF HYPOCOTYL DIAMETER AS A BREEDING TOOL

Devon L. Doney

In the 1974 Sugarbeet Research, we reported findings concerning the genetics and the relationship of the hypocotyl diameter of 3-week-old seedlings with root yield. We are continuing to investigate this character and evaluate its value as a breeding tool.

The original work was conducted in the growth chamber. If this character is to be used in a breeding program, large numbers of plants will have to be tested. The number of plants that can be tested in a growth chamber limits the testing to experimental rather than breeding programs.

We, therefore, set up testing in the greenhouse where much larger numbers of plants can be tested. The major problem confronting greenhouse testing is the larger environmental variances. By controlling the environment factors as much as possible, we have been able to maintain the CV for hypocotyl diameter to ten percent or less on a per plant basis. Some of the efforts to obtain as much uniformity as possible have been: to use overhead lighting shaded on the sunlight side, plant in vermiculite, and water daily with equal amounts of nutrient solution, use 185 ml plastic vials imbedded in moist sand (keeps root temperature constant), and test only plants that emerge on the same day.

A broadbase open-pollinated population was used to test its selection potential. This population was planted in a space-planted (61 cm between plants) field trial. A uniform hybrid was randomized in the trial to obtain an estimate of the environmental variance. All roots were harvested and weighed at five months of age. The same population and hybrid were planted in the greenhouse for the hypocotyl-diameter measurements. In addition to hypocotyl measurement, measurements were made on leaf weight, root weight, and growth partitioning ratio when plants were three weeks old.

The environmental variation was a large part of the total variation in all the measurements except for hypocotyl diameter. This is demonstrated by the F ratio for significant genetic variation (Table 1). In fact, the hypocotyl-diameter character was the only measurement that exhibited a significant genetic variance. It was the only character that exhibited sufficient broad-sense heritability (70%) to expect significant progress (Table 1). The probability of increasing root yield by selecting for hypocotyl diameter or root weight of 3-week-old seedlings was compared, using 5-month-old space-planted roots as a standard. The relative selection efficiency (RSE) for hypocotyl diameter was 1.46 compared to 0.39 for root weight (Table 1). This can be read as: the probability of increasing root yield by selecting for hypocotyl diameter is 1.46 times greater than selecting for root weight in 5-month-old space-planted beets.

Several broadbase populations were tested for hypocotyl diameter and later tested in the field in a replicated field trial (Table 2). Hypocotyl measurements tended to predict the root yield (Table 2).

The most important population was d49. Thirty lines from this population were tested for hypocotyl diameter. Seed from the eleven lines having the largest hypocotyl measurements were mixed together for the field test and represent entry #1006. Seed from the 19 small hypocotyl-diameter lines were mixed together and represent entry #1005 in the field test (Table 2). The large hypocotyl diameter entry (#1006) yielded six tons per acre more than the small hypocotyl diameter entry (#1005) (Table 2). The difference in yield was 3.5 times the least significant difference (LSD) whereas the difference in hypocotyl diameter was 4.8 times the LSD. These differences can best be illustrated in graphic form (Figure 1). The percentage differences for gross sugar and root yield are about the same as for hypocotyl diameter. However, the LSD for hypocotyl diameter is much smaller than for root yield, indicating the increased precision achieved in this measurement. The large hypocotyl diameter entry (#1006) was lower in percent sugar than the small hypocotyl diameter entry (#1005) (Figure 1). By selecting for yield, we inadvertently reduced the sugar percentage. This points out the need for looking at sugar concentration as well as yield. We are presently attempting to find ways to select for sugar potential as well as yield potential.

We feel this technique has a place in a breeding program, particularly in the early stages of a recurrent selection program. It is less expensive than yield trials, more accurate than space-planted trials, and requires less evaluation time. We are currently testing its effectiveness in a recurrent selection program.

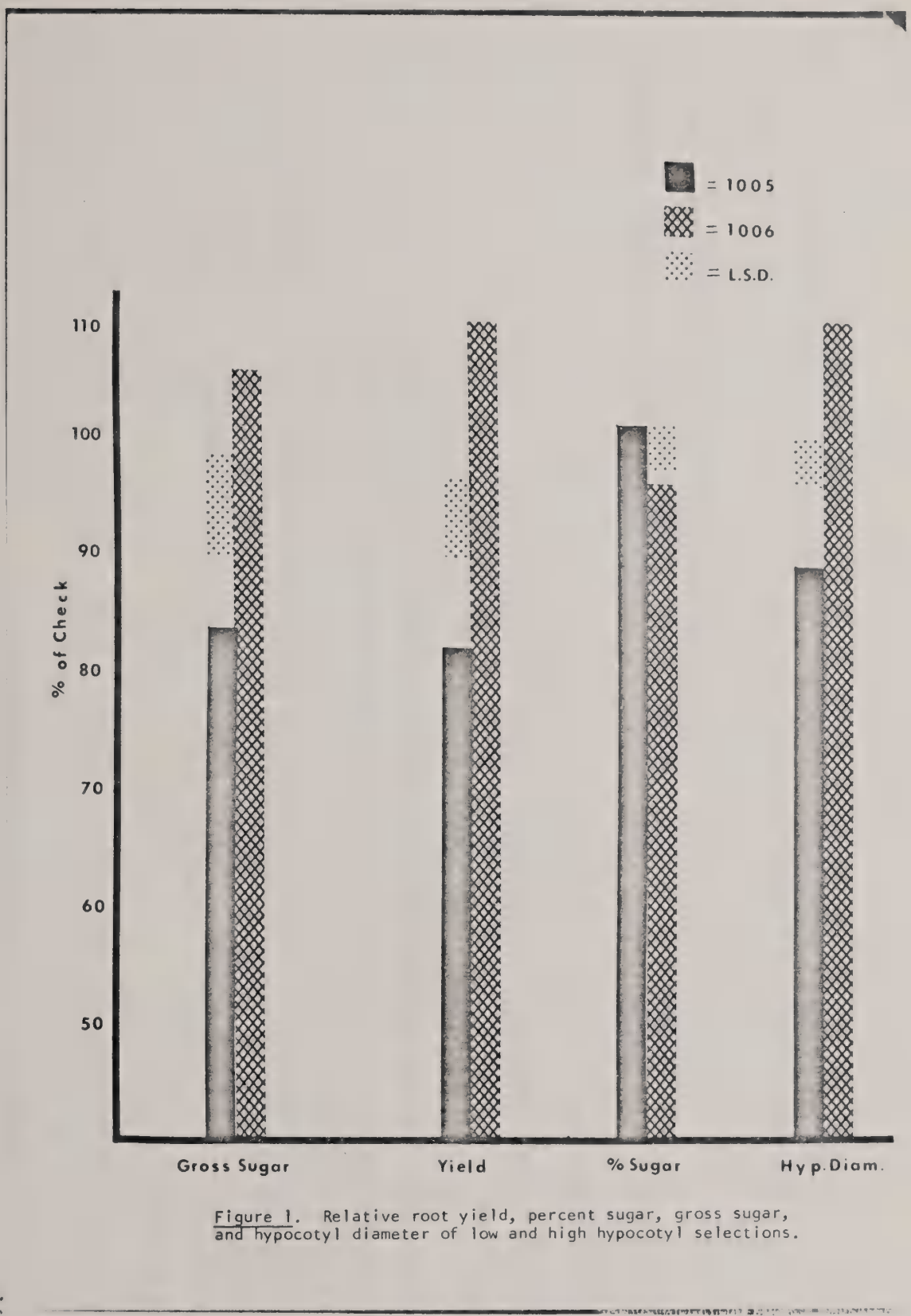

Figure 1. Relative root yield, percent sugar, gross sugar, and hypocotyl diameter of low and high hypocotyl selections.

Table 1. F ratio for significant genotypic variance and broad sense heritability for root weight of 5-month-old plants and hypocotyl diameter, root weight, leaf weight and growth partitioning ratio of 3-week-old seedlings.

	5-month-old	3-week-old Seedlings			
	Root Weight*	Hypocotyl Diameter	Root Weight	Leaf Weight	Growth Partitioning Ratio
F ratio for significant Genotypic Variance	1.18	3.06**	0.85	1.03	0.90
Broad Sense Heritability	15	70	-15	3	-11
RSE[a]	1.00	1.46	.39		

* = Space planted in field (61cm in row and 56cm between rows)

** = Significant at p = 0.01

a = Relative selection efficiency of increasing root yield compared increasing root yield by selection for root weight in 5-month-old space planted beets.

Table 2. Yield, sugar percentage and quality factors for hypocotyl diameter selection populations - Logan, 1975.

Code	Description	Gross Sugar Lbs./Acre	Tons/Acre	% Sugar	Nitrogen PPM	Sodium PPM	Potassium PPM	Index	Hypocotyl Diameter (mm)
1001	Sub-population of AN0 Broadbase	7276	24.1	15.1	622	184	1838	760	2.57
1002	AN0 Broadbase	7643	25.3	15.1	531	174	1827	697	2.61
1003	D14 Broadbase	6017	20.6	14.6	727	78	1452	771	2.04
1004	Sub-population of D14 Broadbase	5971	19.1	15.6	557	78	1584	627	2.02
1005	Low Hyp. Dia. Lines of d49	5724	18.7	15.3	518	88	1429	592	2.00
1006	High Hyp. Dia. Lines of d49	7188	24.7	14.6	525	108	1851	702	2.48
1007	US22/3	6584	22.1	14.9	589	123	1355	651	
1008	U&I Hy. #7	7985	25.9	15.4	602	98	1138	599	
F ratio		13.6**	14.3	3.3**	3.6**	8.8**	4.8**	3.1**	
LSD		648	1.7	0.6	101	39	333	108	
CV		8.2	8.0	3.3	15.3	29.4	18.9	14.1	
Mean		6758	22.4	15.1	584	117	1560	675	

GENOTYPIC GROWTH ANALYSIS

D. L. Doney, R. Wyse, J. C. Theurer

This was the initial year for our research program to determine the morphological, physiological, and biochemical factors limiting root and sucrose production. The purpose of this phase of the program was to evaluate the genetic and phenotypic relationship of a large number of growth factors. This large number of factors was evaluated to 1) provide a good look at the overall plant and 2) to point out factors and relationships that should be emphasized in subsequent studies.

Factors selected for this study were: root fresh and dry weights, petiole fresh and dry weights, blade fresh and dry weights, root, petiole and blade percent dry matter, percent sugar, root diameter, ring number, ring width of the first five rings, and invert sugar. Other biochemical and photosynthetic factors were also studied but will be reported elsewhere.

Methods

Twenty-four inbreds and hybrids differing in sugar content, root yield, and combining ability were selected for this study. Part of this group involved nine inbreds (known to transmit different degrees of heterosis) crossed to the same female parent (L29). This makes it possible to study the growth and biochemical factors that exhibit and effect heterosis.

The test was planted in a split-plot randomized block (6) design, with harvest dates (6) as whole plots and entries (24) as subplots. Each plot consisted of two 16-foot (4.88 m) rows. Harvest dates were: July 2, July 28, August 28, September 8, September 29, and October 16. Data were taken on 10 feet (3.05 m) of each of the two-row plots. Percent dry matter was determined from a random sample of each plot. Ring-number and ring-width measurements were made on five randomly selected roots from each plot. Discs from the widest part of the root were stored at least 24 hours prior to the ring number and width measurements. All other measurements were made on a whole-plot basis.

Results

Growth Curves - Figures 1 and 2 show the growth curves for each of the factors. These curves are for all of the entries. The days on the horizontal axes of the figures are for days after thinning (June 10). The proportion of the total photosynthate partitioned to the three plant tissues (blade, petiole, and root) was about equal up to July 28. At that time the sink strength became dominant and

received a much larger proportion of the total photosynthate for the remainder of the growing season (Fig. 1, Fresh Weight and Dry Weight). All three tissues increased in percent dry matter throughout the season (Fig. 1, Percent Dry Matter). The root was highest in percent dry matter and increased more rapidly than the blade and petiole. However, the proportionate relationship among the three remained constant on a percent dry matter basis, with the blade 83 percent and the petiole 63 percent of the root. The root/shoot ratio also increased throughout the season because of the more rapid growth of the root (Fig. 1, Root/Shoot Ratio).

Percent sugar increased in a linear fashion from July 28 to the final harvest (Fig. 2, Percent Sugar). However, there appeared to be a leveling off in sugar concentration at the last harvest date. This is contrary to popular belief that sugar concentration increases more rapidly during this period of time. This leveling off might be due to differences in water content as a result of a heavy storm that preceded the final harvest. The gross sugar gives a more true picture by eliminating effects due to differences in water content. The gross sugar increased on almost a straight line from July 28 to the final harvest on October 16 (Fig. 2, Gross Sugar).

Ring number increased from an average of 7.7 rings on July 28 to 10.3 on October 16 (Fig. 2). Rings grew at about the same rate; i.e., as each succeeding ring was initiated, it grew at the same rate as the previous rings. Their plotted growth curves resulted in a series of parallel growth curves (Fig. 2, Ring Width).

The growth curves of the individual lines for most of the growth factors were parallel. For example, the highest yielding lines at the first harvest were the highest at the last harvest. There was one important exception to this (sugar percent). All the inbreds increased in sugar concentration at the same rate (lines were parallel, Fig. 3) except inbred L19. Inbred L19 is a very high-sugar line. On July 28, it was one of the lowest inbreds in percent sugar but increased at a much faster rate and ended up with a 2.7 percentage points higher sugar concentration than any other inbred (Fig. 3). In addition, the L19 hybrid had a much faster rate of sugar accumulation than the other hybrids.

Heterosis - Significant heterosis (greater than the mid-parent) was observed for all factors measured (Table 1). There was considerable variation among the inbreds for heterosis. Inbreds were not consistent in their heterotic effect over all factors; i.e., inbred L33 gave little heterosis for petiole weight but exhibited one of the largest heterotic effects for root weight (Table 1). A negative heterotic effect was observed for percent dry matter, especially in the petiole. For some reason, the hybrid petioles had more water than the inbreds, particularly for inbreds L21, L53, and F5 (Table 1). Some inbreds exhibited heterosis for percent sugar and ring number. Those inbreds showing heterosis for ring number were the same inbreds that gave heterosis for percent sugar

(Table 1). There was some heterosis (both negative and positive) for invert sugar (Table 1). However, these data are in mg/kg of fresh weight and amounts to such a small percentage of the total sugar that it may have little practical meaning.

Correlations - Correlations were calculated between all factors, between harvest dates, and between inbreds, hybrids, and for heterosis. Many of the correlations are small and have little meaning. We are including in this report only those relationships that appear to be important. Harvest dates for most growth factors were closely correlated, indicating that the most vigorous lines are the most vigorous throughout the growing season. The one exception to this was the accumulation of sugar which was discussed above. Following is a list of the most important relationships gleaned from the massive number of correlations generated: (Correlation coefficients are in parentheses.)

1. Root percent dry matter correlated with:
    a. Blade and petiole percent dry matter (0.48 and 0.74)
    b. With percent sugar (.80)
    c. Negatively with fresh weight (-0.77)
    d. With ring number (0.61)
2. Root fresh weight correlated with:
    a. Blade and petiole fresh weight (0.77 and 0.86)
    b. Root Diameter (0.75)
    c. Negatively with percent dry matter (-0.54)
3. Ring number correlated with:
    a. Percent sugar (0.61)
    b. Percent dry matter (0.68)
4. Heterosis for ring number correlated with:
    a. Heterosis for percent sugar (0.77)

5. Inbreds high in percent sugar correlated with:
    a. Hybrids high in percent sugar (0.91)
    b. Hybrids high in ring number (0.65)
    c. Hybrids high in percent dry matter (0.83)
6. Low-yielding inbreds correlated with:
    a. Greatest heterosis for root weight (-0.75) but not necessarily with the hybrids (0.05)
7. High-yielding inbreds correlated with:
    a. Low percent dry matter (-0.77)
    b. Heterosis for percent dry matter (0.61)
    c. Heterosis for percent sugar (0.55)

In an effort to understand more about the mechanisms of sugar accumulation, we calculated the kilograms of sugar per kilogram of dry matter and water (Table 2). The kilograms of sugar per kilogram of dry matter seemed to be unrelated with the sugar concentration with a correlation of -0.10. The kilograms of sugar per kilogram water was highly correlated (0.97) with percent sugar (Table 2). Thus, the reason a given inbred is higher in sugar concentration than another is not because more of the photosynthate going to the root is sugar, but because there is less water per unit of sugar.

There are some very interesting physiological and genetic relationships pointed out by these data that need further investigating. A more thorough investigation will be made of these important relationships in this coming year's research.

Table 1. Relative Heterosis for each inbred over all measured factors.

	Fresh Wt. (lbs/plot)			Dry Wt. (lbs/plot)			% Dry Matter			%	Ring	(cm) Root	Invert Sugar
	Blade	Petiole	Root	Blade	Petiole	Root	Blade	Petiole	Root	Sugar	No.	Diam.	(mg/kg)
L19	1.36**	4.69**	8.39**	0.25**	0.39**	1.70**	0.31	-1.12**	0.02	0.40**	-0.22	1.07**	-122**
L21	7.36**	14.11**	12.74**	1.12**	1.13**	2.45**	-0.57**	-2.93**	-1.18**	0.23	0.12	1.51**	- 7
L33	3.23**	4.35**	10.80**	0.38**	0.34**	2.08**	-0.96**	-1.08**	-0.52**	0.44**	0.29**	1.48**	155**
L35	1.91**	3.44**	5.99**	0.28**	0.31**	1.32**	-0.21	-1.13**	-0.36	0.79**	0.76**	0.47**	40
L36	2.55**	5.17**	6.66**	0.39**	0.43**	1.49**	0.26	-0.37	0.23	0.42**	-0.02	0.64**	-100**
L38	1.80**	5.55**	11.33**	0.25**	0.40**	1.85**	-0.04	-0.28	0.17	0.70**	0.59**	1.20**	130**
L53	5.14**	9.65**	13.57**	0.56**	0.76**	2.63**	-1.21**	-2.66**	-0.41	0.16	0.14	1.33**	47
00.5	1.50**	6.64**	4.30**	0.58**	0.53**	0.80**	0.72**	-0.70**	0.12	0.71**	0.58**	0.27	170**
F5	3.93**	9.15**	9.83**	0.51**	0.76**	2.04**	-0.73**	-1.99**	-0.36	0.63**	0.43**	1.47**	- 24
C17 X C97	3.93**	9.59**	8.61**	0.59**	0.65**	1.52**	-0.29	-0.92**	-0.12	0.22	0.32**	0.97**	-204**
Mean	3.27**	7.23**	9.22**	0.49**	0.57**	1.79**	-0.27**	-1.32**	-0.17	0.47**	0.30**	1.04**	9
** Significant at p = .01	.92	1.46	2.52	0.15	0.16	0.65	0.75	0.69	0.69	0.37	0.34	0.38	109

Table 2. Kilograms of sugar per kilogram of water and dry matter for each inbred.

Inbred	Kg Sugar/kg Water	Kg Sugar/kg Dry Matter
L19	0.25	0.72
L21	0.21	0.63
L33	0.20	0.67
L35	0.21	0.66
L36	0.20	0.70
L38	0.16	0.83
L53	0.20	0.68
005	0.18	0.67
F5	0.19	0.62

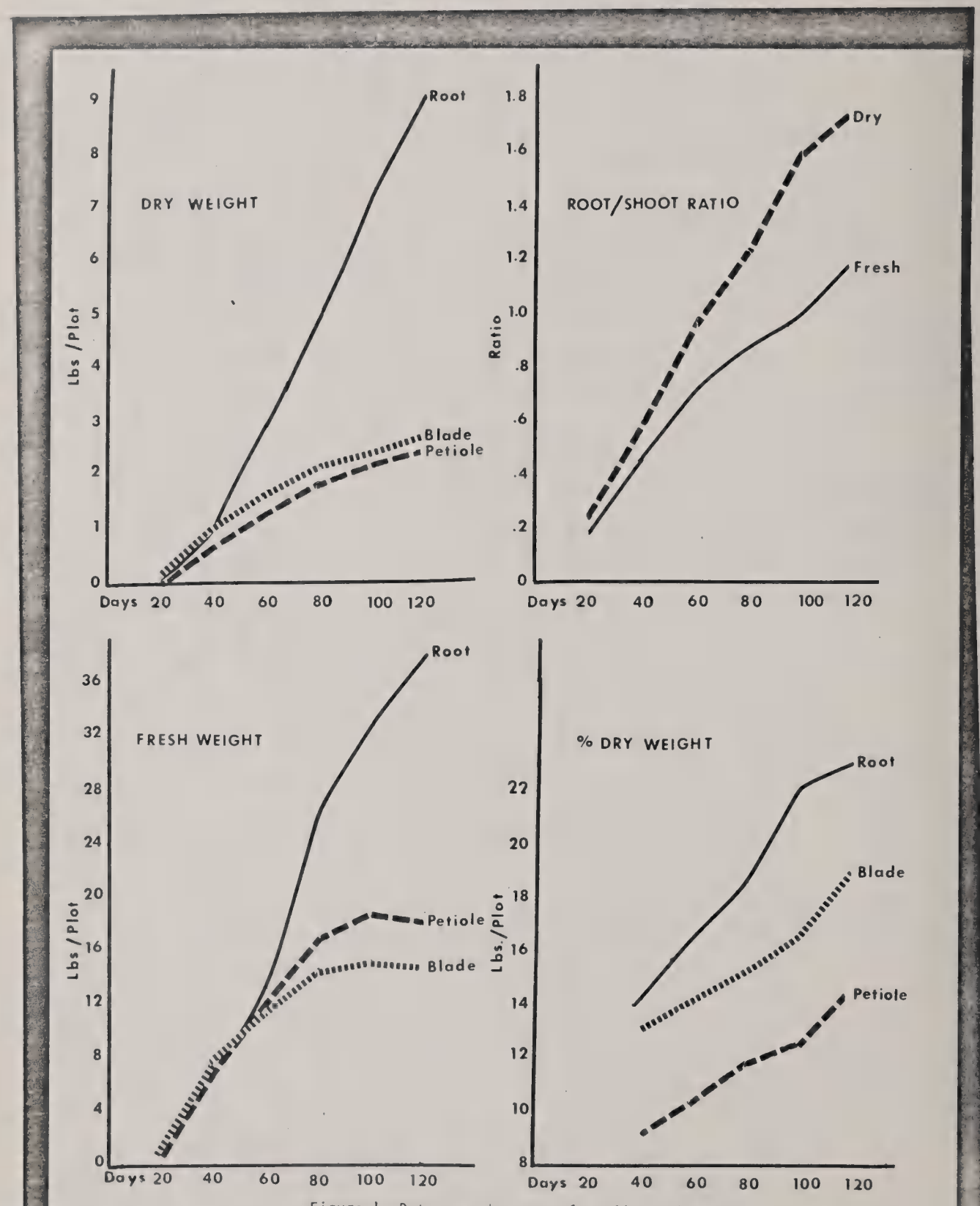

Figure 1. Data over harvests for all entries.

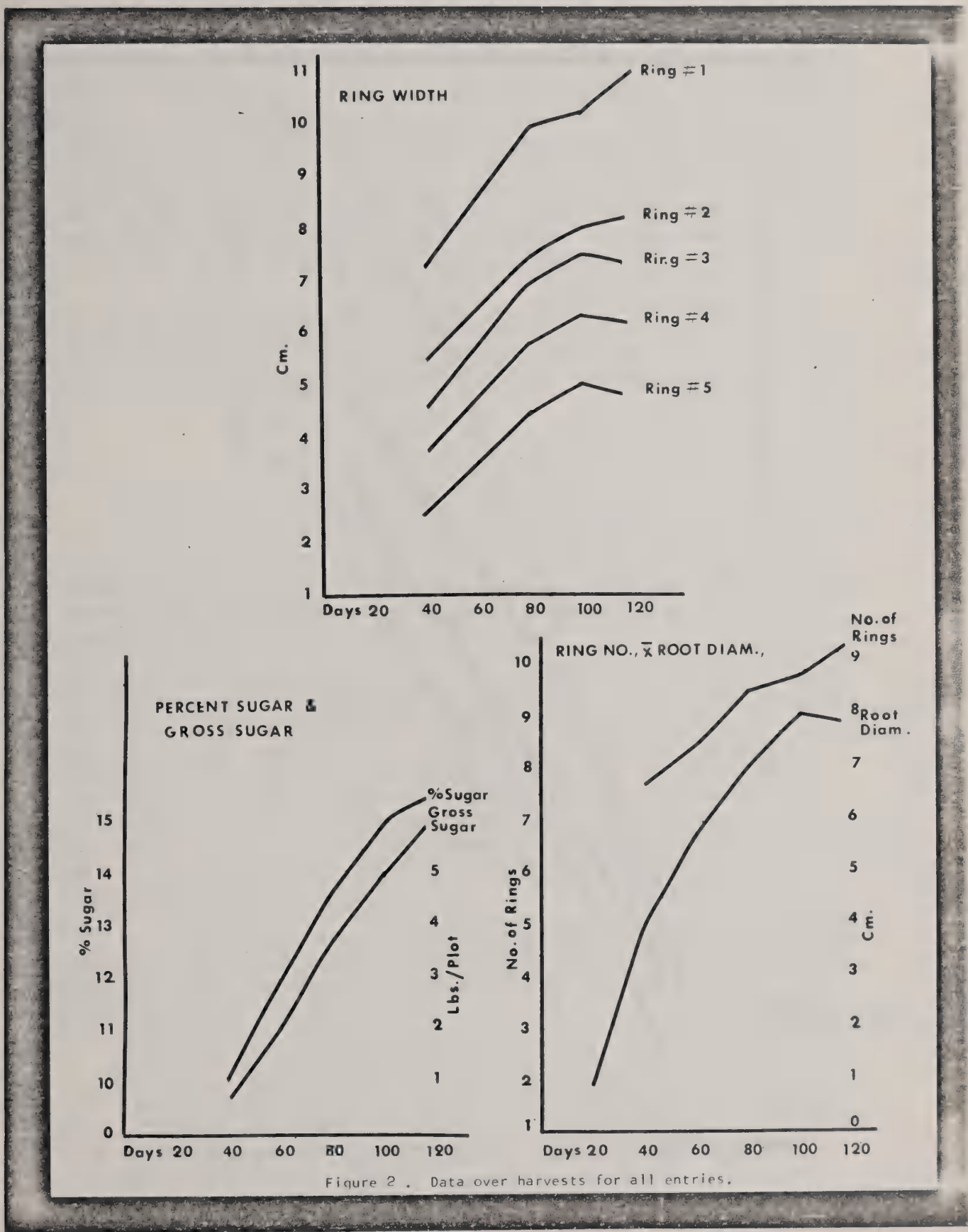

Figure 2 . Data over harvests for all entries.

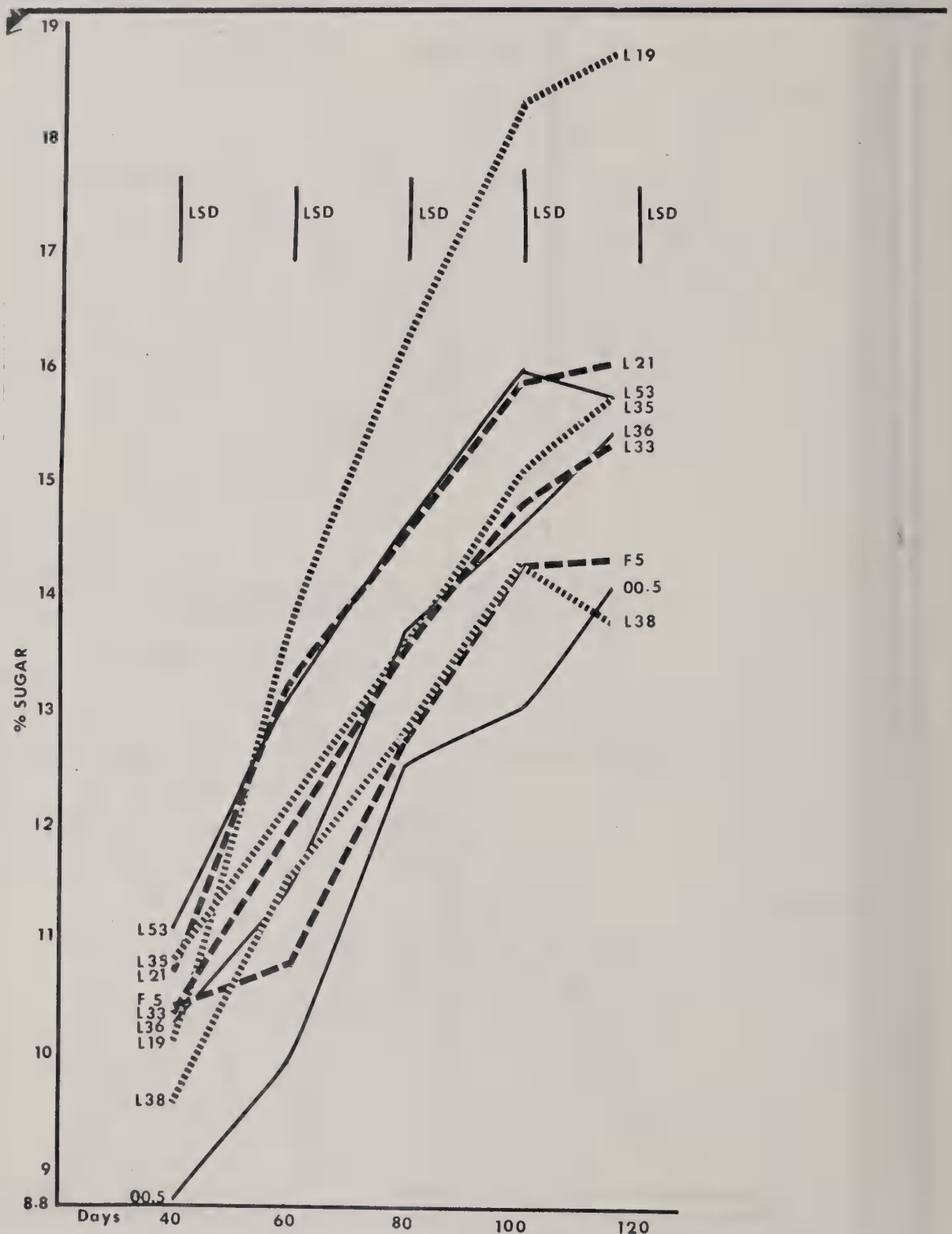

Figure 3. Percent Sugar of Inbreds

- GROWTH ANALYSIS OF INBREDS AND HYBRIDS IN A SPACE PLANTED NURSERY

J. C. Theurer, D. L. Doney, R. E. Wyse

In 1975 a study was initiated at Logan to identify the major growth factors that influence sugar production. One ultimate goal is to develop selection techniques that will speed up the process of screening genetic material and selecting those genotypes that will give greater sucrose yield. Morphological, physiological, and biochemical determinations with contrasting genotypes must be evaluated in order to develop a valid selection model.

This experiment was established at the University Evans Farm at Logan to compare some of the morphological growth factors of inbreds of diverse genotype and also to note the relationship of morphological characters of high yield and high sugar-type inbreds with their F_1 hybrids.

Materials and Methods

Seed of thirteen inbreds and eight hybrids were drilled June 17, 1975, in single rows 20 feet long and rows 22 inches apart. There were six replicates in the test with commercial varieties HH22 and GWD2 planted on the left and right sides of the plots as buffer rows. Plants were meticuously thinned, using a measuring stick so as to space plants 15 inches apart.

When the plants were approximately four weeks old, five representative plants were selected in each row for morphological characterization. Individual leaves of these plants were identified by attaching a numbered plastic tag to each leaf petiole as the leaf developed. The accretion of leaves was noted at approximately ten-day intervals. At these intervals, a measurement was made of the width and length of each living leaf, using a 1 cm square grid chart. A simplified estimate of the average leaf area was made by multiplying the leaf width x the leaf length. A record of the number of dead leaves was also made.

On September 18, the plots were harvested. Tops were removed by hand and root weight and top green weight were immediately determined. Root/top ratio was calculated on a field weight basis.

Results and Discussion

The mean root weights of hybrids and inbreds and heterosis for this character are given in Table 1. C17 was the highest yielding inbred and L53 was the lowest. General combining ability for L53

was very evident in the hybrids. Hybrids L53XL37 and L53XL38 gave the greatest heterosis. All crosses, except L29XL19, showed heterosis for root weight. L19 had the highest sugar percentage of the inbreds and was a parent of the hybrids having the greatest sugar content (Table 2). L29 and L38 appeared to give the greatest heterosis for sugar.

Gross sugar of C17 and L37 surpassed the other inbreds (Table 3). L53XL37 was the top sugar yield hybrid. Significant heterosis was observed for each inbred line.

The green weight of the tops is given in Table 4. C17, L38, L8, and F5 had the largest tops. L53 and A7135 had the smallest tops. L19 and L53 showed significant heterosis for green weight of leaves.

A7135, L37, and L21 had the greatest root/top ratio of the inbreds (Table 5). L18 and F5 had greater top weight than root weight (root/top ratio < 1.0). There was significant heterosis for a better ratio, i.e., hybrids had larger roots per top weight than the mid-parent value would indicate. L37 gave the best root/top ratio in the hybrids.

The number of leaves produced by each inbred from the middle of July to September 2 is shown in figures 1a and 1b. The inbreds were divided into two groups for these figures, mainly on the basis of high yield type and high sugar. However, the main reason for division was to eliminate the difficulty of trying to place all thirteen inbreds on a single graph. There was a steady increase in the number of leaves for all of the inbreds. C17 had the greatest number of leaves and L37 had the least number of leaves. The high-sugar inbred L8 had a large number of leaves and high-sugar inbred L19 was among the inbreds having the least number of leaves. These results demonstrate that there is no apparent relationship of the number of leaves with either root weight or sucrose content of the root. L29 hybrids had the lowest number of leaves in the crosses which is as would be expected on the basis of the number of leaves in the inbred (Fig. 2). L53 showed the opposite result, as its inbred and hybrids had the largest number of leaves (compare Figs. 1a, 1b, and Fig. 2). L29 and L19 gave heterosis for fewer leaves.

Leaf area, leaf width, and leaf length all followed a similar pattern. There was rapid growth of the foliage during the latter part of July and the first part of August. Then leaf area developed at a slower rate and, ultimately, in the latter part of August, there was a decrease in the mean leaf area. Since there was a steady increase in the number of leaves, the decrease in mean leaf area indicates that the new leaves at the end of the growing season were consistently smaller for all entries than early in the season. Comparison of Figures 3a, 3b, and 4 shows that hybrids begin decreasing in leaf area sooner than inbreds. One exception was inbred A7135 (R2) which began to decrease in leaf area as early as August 4.

Inbreds C17 and L8 had the highest mean leaf area while inbred L53 had significantly smaller leaves among the inbreds. On the average, L53 and L19 gave the greatest mean leaf area of the hybrids (Fig. 4). However, with the exception of A5XL37, the hybrids were fairly similar in mean leaf area at the end of the growing season. The decrease from August 11-12 to September 2 was significantly correlated with root yield (.78* for hybrids and .82** for all entries).

Figures 5a, 5b, and 6 show the number of dead leaves observed for inbreds and hybrids over the growing period. There was a constant increase in the number of dead leaves for both inbreds and hybrids which correlates very well with the total number of leaves produced (Figs. 1a, 1b, and 2). L53 and L33 had the greatest number of leaves that died during the season. L37, L38, and L19 had the least number of dead leaves. L19 hybrids had the greatest number of dead leaves of the hybrids. L53 and L29 gave heterosis for fewer leaves dying.

General Conclusions

1. Inbred morphological growth characteristics tell very little about hybrid performance. Some hybrids show a relationship to their inbred parents for a given character and others do not. There is no consistency.

2. There appears to be heterosis for 1) root yield, 2) top yield, 3) leaf area, 4) leaf width, 5) leaf length, 6) root/top ratio, 7) number of leaves, and 8) number of leaves dying. There are also different degrees of heterosis for each of the above characteristics.

3. Early growth and decrease in leaf area are associated with root weight.

Table 1. Mean root weight of inbreds and hybrids and heterosis, South Farm growth analysis experiment, 1975.

Inbred	T/Ac.	Hybrid	T/Ac.	Mid-Parent T/Ac.	Heterosis T/Ac.
L8	8.50	L53 X L37	16.53	8.66	7.87**
L18	5.84	L29 X L37	15.64	10.39	5.25**
L19	9.01	A5 X L37	14.36	9.95	4.41**
L21	9.11	L53 X L38	14.36	8.36	6.00**
L29	9.50	L29 X L38	14.65	10.09	4.56**
L33	8.61	L53 X L19	13.07	7.52	5.55**
L37	11.29	L29 X L19	10.49	9.25	1.24
L38	10.69	A5 X L19	12.57	8.31	4.26**
L53	6.04				
A5	8.61				
A7135	8.02				
C17	13.07				
F5	7.62				

** = Significance at 1% point

LSD - .05 for inbreds and hybrids = 1.67

Table 2. Sucrose percent for inbreds and hybrids and heterosis, South Farm growth analysis experiment, 1975.

Inbred	Percent	Hybrid	Percent	Mid-Parent Percent	Heterosis Percent
L8	14.6	L53 X L37	14.9	14.5	0.4*
L18	14.8	L29 X L37	14.8	13.7	1.1**
L19	16.4	A5 X L37	14.9	14.2	0.7*
L21	14.5	L53 X L38	14.8	14.1	0.7*
L29	13.2	L29 X L38	14.6	13.3	1.3**
L33	13.1	L53 X L19	16.1	15.6	0.5*
L37	14.2	L29 X L19	15.8	14.8	1.0**
L38	13.4	A5 X L19	15.6	15.3	0.3
L53	14.8				
A5	14.1				
A7135	14.0				
C17	13.5				
F5	14.0				

* = Significance at 5% point
** = Significance at 1% point

LSD - .05 for inbreds and hybrids = .50

Table 3. Gross sugar for inbreds and hybrids and heterosis, South Farm growth analysis experiment, 1975.

Inbred	Lb/Ac.	Hybrid	Lb/Ac.	Mid-Parent Lb/Ac.	Heterosis Lb/Ac.
L8	2782	L53 X L37	4929	2486	2443**
L18	1734	L29 X L37	4614	2849	1765**
L19	2968	A5 X L37	4262	2810	1451**
L21	2630	L53 X L38	4238	2327	1911**
L29	2511	L29 X L38	4288	2690	1598**
L33	2259	L53 X L19	4193	2376	1816**
L37	3187	L29 X L19	3329	2739	589*
L38	2869	A5 X L19	3922	2701	1221**
L53	1785				
A5	2434	* = Significance at 5% point			
A7135	2251	** = Significance at 1% point			
C17	3507				
F5	2127				

LSD - .05 for hybrids and inbreds = 473

Table 4. Green top weight for inbreds and hybrids and heterosis, South Farm growth analysis experiment, 1975.

Inbred	Wt. Lbs.	Hybrid	Wt. Lbs.	Mid-Parent Weight	Heterosis Weight
L8	15.3	L53 X L37	14.3	10.5	4.30**
L18	13.3	L29 X L37	15.7	13.5	2.20
L19	14.3	A5 X L37	13.7	13.2	0.50
L21	10.3	L53 X L38	13.7	12.8	0.90
L29	14.3	L29 X L38	17.3	15.8	1.50
L33	11.0	L53 X L19	19.0	11.3	7.70**
L37	12.7	L29 X L19	14.0	14.3	-0.30
L38	17.3	A5 X L19	19.0	14.0	5.00**
L53	8.3				
A5	13.7	** = significance at 1% point			
A7135	8.7				
C17	18.7				
F5	15.3				

LSD - .05 for inbreds and hybrids = 2.8

Table 5. Root/top ratio for inbreds and hybrids and heterosis, South Farm growth analysis experiment, 1975.

Inbred	Ratio	Hybrid	Ratio	Mid-Parent Ratio	Heterosis Ratio
L8	1.05	L53 X L37	2.04	1.33	0.71**
L18	0.78	L29 X L37	1.81	1.33	0.48**
L19	1.05	A5 X L37	1.85	1.29	0.56**
L21	1.44	L53 X L38	1.76	1.12	0.64**
L29	1.14	L29 X L38	1.53	1.11	0.42**
L33	1.21	L53 X L19	1.16	1.11	0.06
L37	1.51	L29 X L19	1.36	1.10	0.26*
L38	1.07	A5 X L19	1.11	1.06	0.05
L53	1.16				
A5	1.07				
A7135	1.61	* = Significance at 5% point			
C17	1.09	** = Significance at 1% point			
F5	0.89				

LSD - .05 for hybrids and inbreds = .20

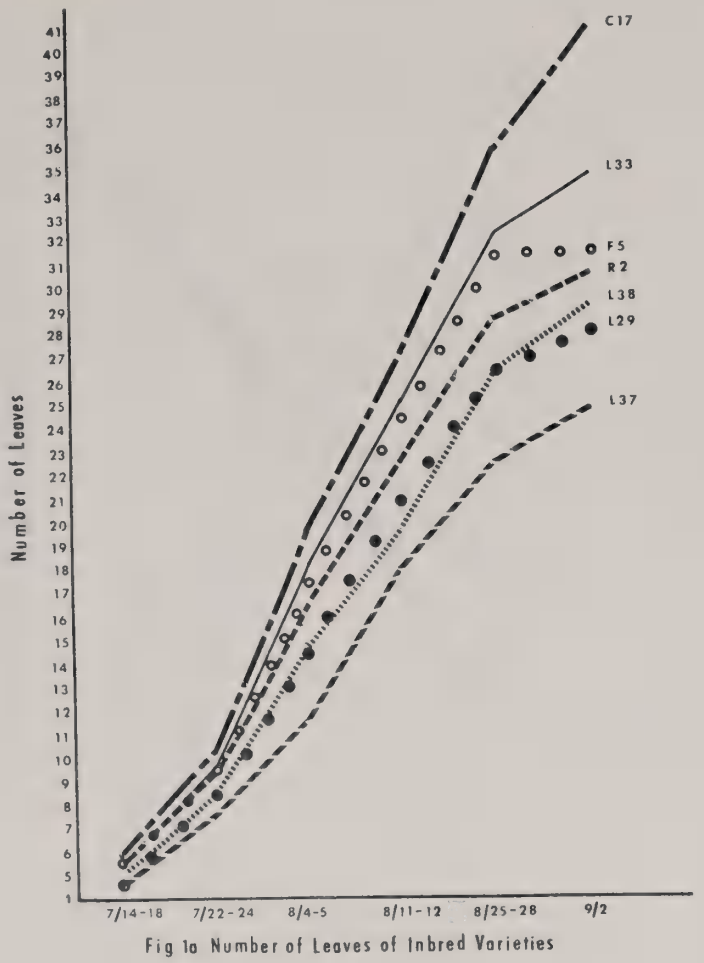

Fig 1a Number of Leaves of Inbred Varieties

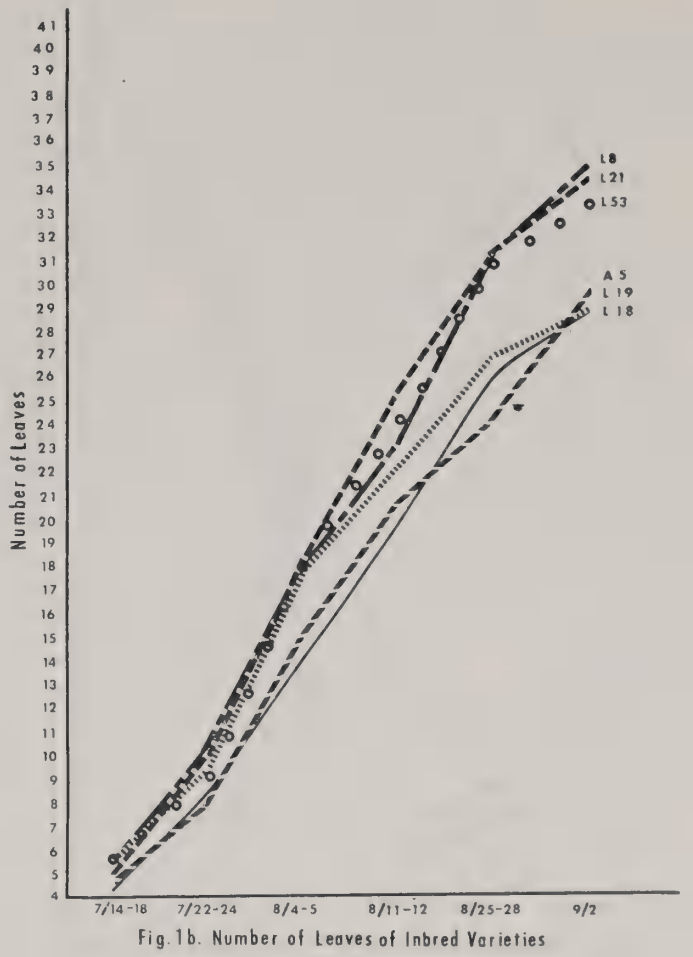

Fig. 1b. Number of Leaves of Inbred Varieties

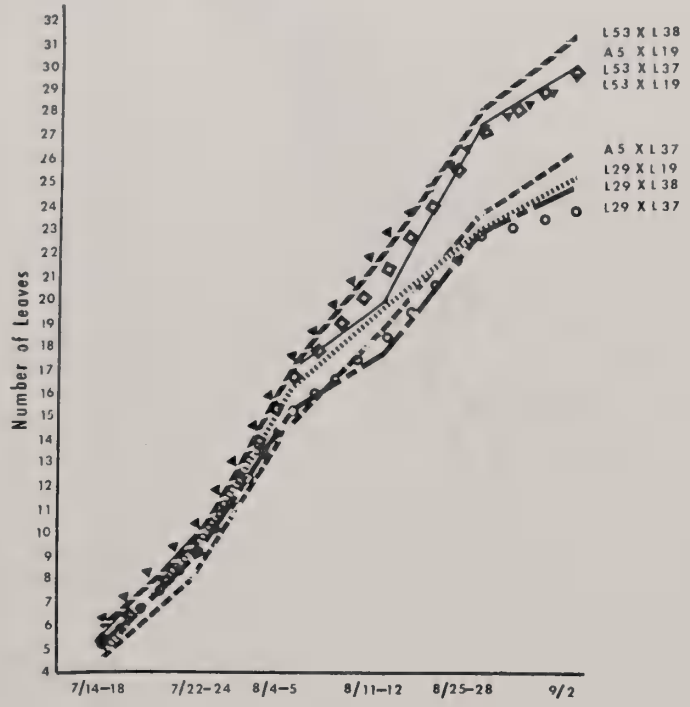

Fig. 2. Number of Leaves vs. Dates – Hybrid Varieties

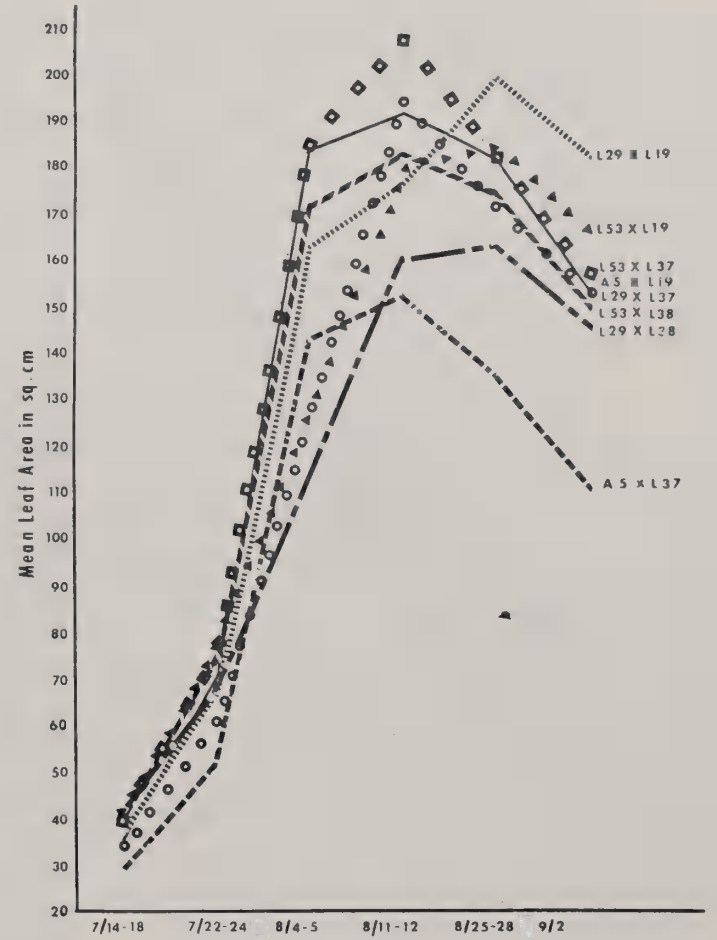

Fig. 4. Leaf Area of Hybrid Varieties

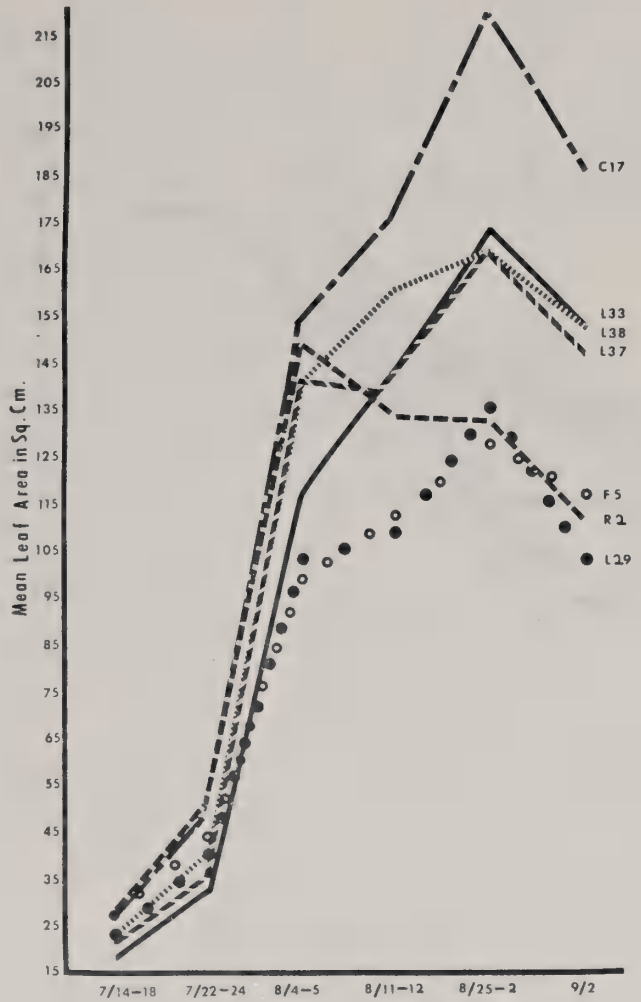

Fig. 3a. Leaf Area of Inbred Varieties

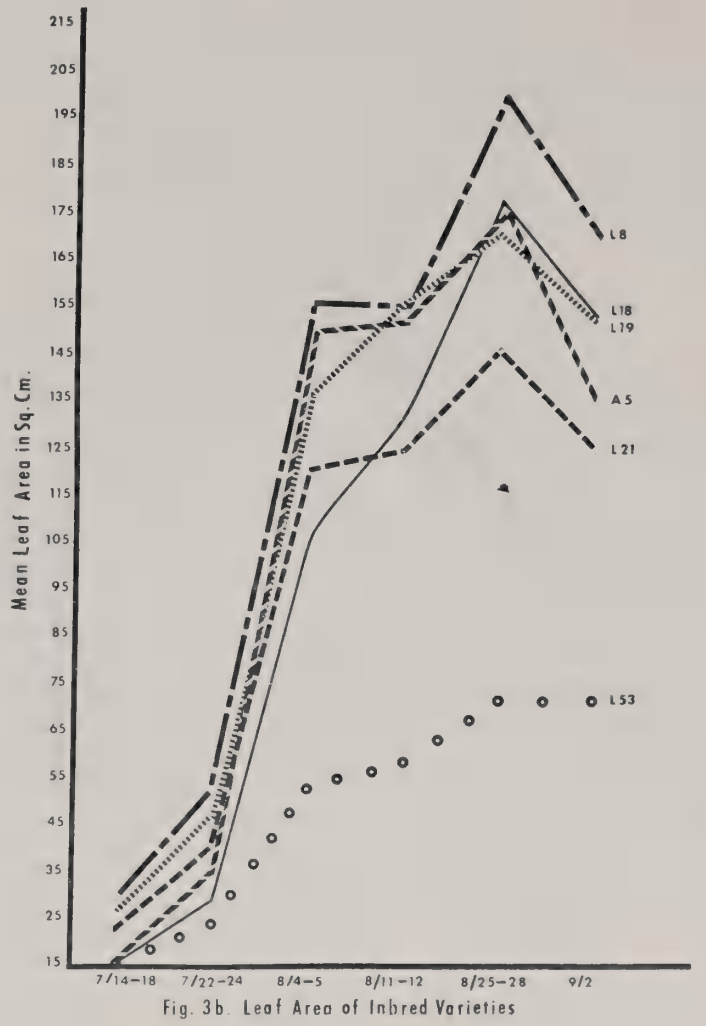

Fig. 3b. Leaf Area of Inbred Varieties

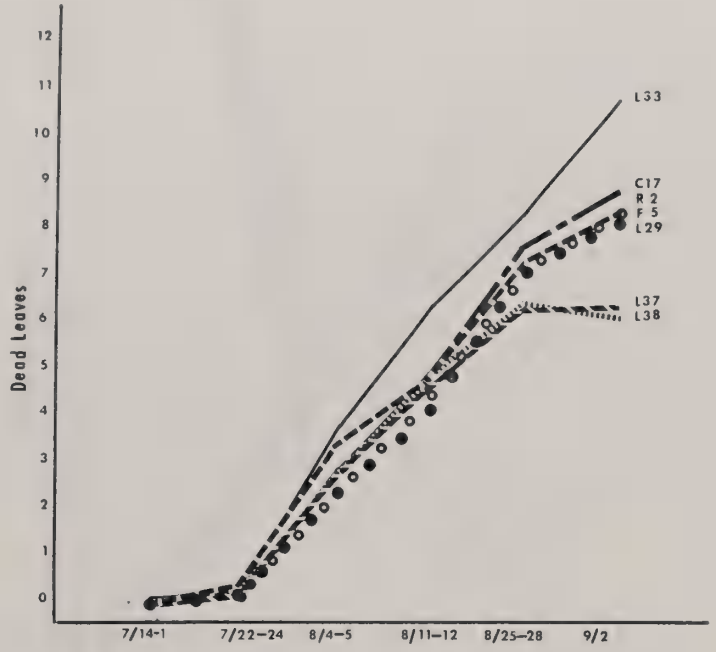

Fig. 5a. Number of Dead Leaves of Inbred Varieties

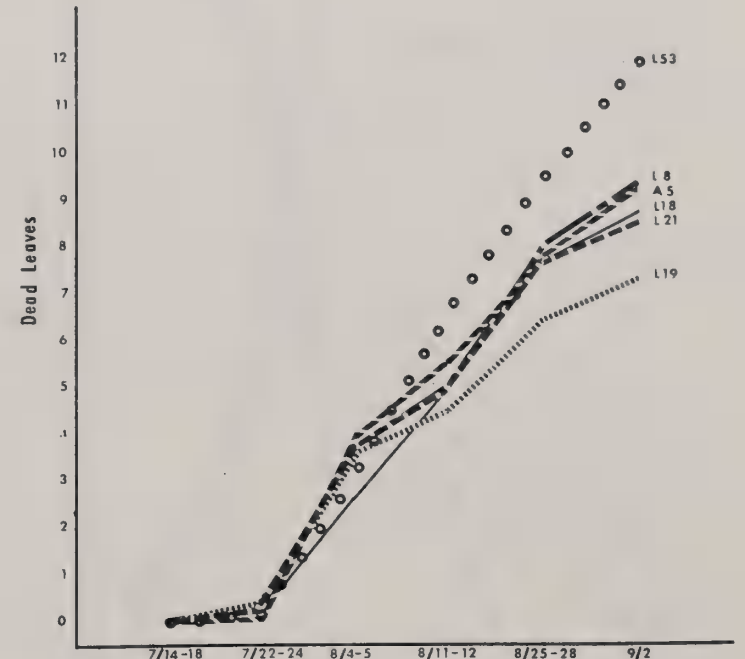

Fig. 5b. Number of Dead Leaves of Inbred Varieties

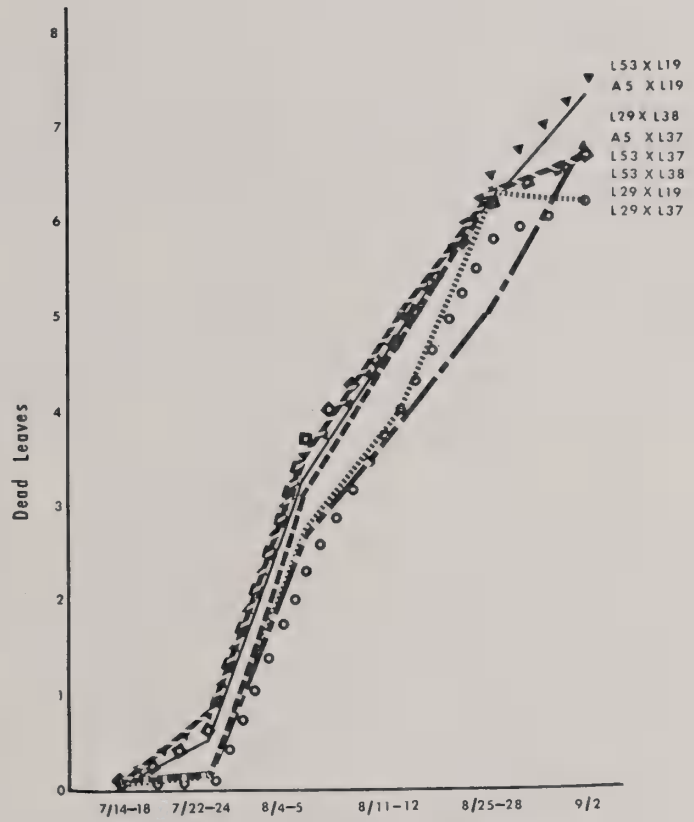

Fig. 6. Dead Leaves vs. Dates – Hybrid Varieties

STUDIES ON THE INHERITANCE OF CURLY TOP DISEASE

J. C. Theurer, D. L. Mumford, and D. L. Doney

In 1936, Abegg and Owen (1) reported that curly top was conditioned by a single partially dominant genetic factor. Murphy, Ryser, and Owen (3) found resistance to be intermediate between that of the parents. Backcrosses of susceptible SLC101 x resistant SL92 gave good resistance in the first backcross to SL92. However, hybrids backcrossed to SLC101 showed only a small percentage of resistant plants (4).

The results of a 1954 field study by Savitsky and Murphy (5) substantiated that curly top inheritance was far more complex than original reports indicated. They concluded that no less than three-to-four pairs of genetic factors are controlling the resistance to this disease. Klein E x SLC101 crosses were more susceptible than either parent. Under mild curly top exposures, curly top resistance appeared to be dominant. Dominance tended to disappear under severe infection. Many susceptible lines were found to carry genes that were partially resistant, and multigerm plants tended to be more resistant than monogerm lines.

With the new resistant inbreds developed at our Station and a technique for greenhouse inoculation that would be more accurate than field observations, we established an experiment to more critically study the inheritance of curly top resistance.

Materials and Methods

Three resistant inbreds, L35, L36, and NB-1, were crossed to three susceptible inbreds, L19, FC503, and E131. The three resistant inbreds were also crossed in every possible combination for a comparison of resistant x resistant breeding behavior. Crosses were made by utilizing the Mendelian male sterile gene a_1, or by emasculation. F_1 plants were self-pollinated and, where possible, backcrosses were made to the parents.

Seed of parent inbreds, F_1 (for four crosses), F_2, and BC_1, generations were germinated in vermiculite in six-inch pots in the greenhouse. Ten-day-old seedlings were transplanted to six-inch pots of soil with four plants per pot, utilizing three to twenty pots as required to grow the germinated seedlings of each line. Each plant was inoculated with the curly top virus by caging two viruliferous leafhoppers on a cotyledon for five days when plants were 25 days old. Three weeks later the plants were assigned grades similar to those outlined by Mumford (2) on a scale from 0 to 9 in which 0 = no infection and 9 = a dead plant.

Results

The mean curly top grades for the parent inbreds and their F_1 and F_2 hybrids are given in Table 1. The three resistant varieties had grades averaging 2.3 and the susceptible lines had an average grade of 6.3. All of the hybrids segregated with grades near the mean of the two parental scores. However, comparison of mid-parent values with the hybrid and F_2 mean grades indicates that both additive and non-additive genetic factors govern curly top resistance. Our data agree with Savitsky and Murphy (5) that curly top disease resistance is governed by multigenic factors.

At this writing, a phase of the experiment is yet in the process of completion. The final results and discussion relative to previous findings on curly top will be published when analysis of this data has been completed.

Table 1. Means of curly top grades for parents F_1 and F_2 generations in greenhouse - 1975.

Cross	P1	P2	Mid-Parent	F_1	F_2
L19 X L35	6.43	2.00	4.21	5.45	4.54
X L36	6.43	2.13	4.28	--	5.20
X NB1	6.43	2.90	4.67	4.26	4.80
FC503 X L35	6.20	2.00	4.10	--	3.40
X L36	6.20	2.13	4.08	--	4.33
X NB1	6.20	2.90	4.56	--	4.72
EL31 X L35	6.17	2.00	4.08	4.45	4.28
X L36	6.17	2.13	4.15	3.87	4.50
X NB1	6.17	2.90	4.50	--	5.10
L35 X L36	2.00	2.13	2.07	--	2.79
X NB1	2.00	2.90	2.63	--	2.93
L36 X NB1	2.13	2.90	2.60	--	2.53

Literature References

(1) Abegg, F. A. and F. V. Owen. 1936. A genetic factor for curly top disease resistance in beets (Beta Vulgaris L.) and linkage relationships. Amer. Nat. 70, pp 36.

(2) Mumford, David L. 1974. Procedure for inducing curly top epidemics in field plots. Journal Amer. Soc. Sugar Beet Technology. 18:20-23.

(3) Murphy, A. M., George K. Ryser, and F. V. Owen. 1952. Performance of F_1 hybrids between curly top resistance and curly top susceptible sugar beets. Proc. Amer. Soc. Sugar Beet Technol. 7:390-392.

(4) Murphy, Albert M. and V. F. Savitsky. 1952. Breeding for resistance to curly top in hybrids with monogerm beets. Proc. Amer. Soc. Sugar Beet Technol. 7:387-389.

(5) Savitsky, V. F. and Albert M. Murphy. 1954. Study of inheritance for curly top resistance in hybrids between mono and multigerm beets. Proc. Amer. Soc. Sugar Beet Technol. 8:34-44, part II.

SOME EFFECTS OF FUNGUS INFECTION ON SUGARBEET ROOTS AND USE OF FUNGICIDES TO REDUCE INFECTION

D. L. Mumford and R. E. Wyse

In recent years, the covering of sugarbeet storage piles has greatly reduced losses due to freezing and thawing. This practice, however, has not reduced losses from fungus deterioration of stored roots. In fact, pile covering often provides a more favorable environment for fungus growth.

The objective of this research was to obtain information on the effect of fungus infection on sugarbeet roots and to determine whether fungicides would be an effective control measure.

Materials and Methods

The fungi used in these studies consisted of an isolate of Penicillium and one of Botrytis obtained from infected beet roots taken from a storage pile at Quincy, Washington. To study the effect of infection by these fungi, a method of obtaining predictable amounts of infection on roots was developed. Roots were injured, using a small 1x2x6-inch board pierced by 12 small nails within a circular area 3 cm in diameter and protruding 3 mm through the board. The nail points were pressed against the root surface and then rotated to produce a circular injury 3 cm in diameter and 3 mm deep. This injured area was inoculated with one of the fungi and then stored under humidity (98%) and temperature (15 C) conditions favorable for infection. Fungus inoculum was prepared from colonies grown in petri dishes on potato dextrose agar (PDA). The agar disk was chopped in a blender for a very brief period of time so as not to liquify the agar. The agar was then separated from the mycelium and spores by straining through cheesecloth.

Respiration rate of roots was determined by measuring carbon dioxide evolution with a flow-through system. The amount of reducing sugar accumulated was determined, using dinitrosalicylic acid on leaded juice (1). In the experiment to determine reducing sugar accumulation, a mixture of the two fungi was used as inoculum; however, growth of Penicillium dominated.

The procedure for initial evaluation of fungicides consisted of measuring inhibition of fungus growth on an agar medium. Disks of filter paper saturated with a particular concentration of fungicide were positioned an equal distance apart around the outer edge of a petri dish containing 20 ml of PDA. The fungus was seeded in the center and allowed to grow toward the filter paper disks (Fig. 1). Inhibition of growth was measured in two to three days.

Superior fungicides selected by this method were tested directly on roots. Injured roots were inoculated and then treated with spray applications of 100, 250, 500, 750, 1000, and 1500 ppm of fungicide. Evaluation of fungicide effectiveness was based on visual observation of fungus growth and measurement of root respiration rate.

Results

Effect of fungus infection on root respiration rate and reducing sugar accumulation.

Several experiments showed that respiration rate of roots increased when they became infected. Respiration was measured three weeks after inoculation, during which time the roots were held at 15 C. Figure 2 shows that respiration rate increased as the percent of surface area infected increased. Roots with 20 percent of their surface area infected with Botrytis had a 100 percent higher respiration rate than injured but uninfected controls. Similar results occurred with roots infected with Penicillium. Injured but non-inoculated roots, which had little or no fungus infection, had less than a five percent increase in respiration rate.

The results, relating amount of reducing sugars accumulated with percentage of root surface area infected, are presented in Figure 3. When fifteen percent of the root surface area was infected, there was a three-fold increase in reducing sugars over uninfected roots. Based on measurements of cores taken through the root, it was apparent that, although the amount of reducing sugars was highest in the immediate area of infection, the increase was present throughout the root.

Evaluation of fungicides in reducing infection of sugarbeet roots by Penicillium and Botrytis.

Sixteen fungicides (Table 1) were evaluated by the agar plate method. Of the four fungicides causing the greatest inhibition of fungus growth (Table 2), benomyl and thiabendazole were selected for testing on sugarbeet roots.

Based on visual observation of fungus growth and measurement of root respiration rate, complete control of infection was obtained by a spray application of either fungicide at a concentration of 500 ppm. A spray application of 500 ppm similar to the one we used was estimated by Merck and Company to leave about 0.5 ppm fungicide on an average one-pound root. Fungus growth on roots treated with concentrations as low as 100 ppm was greatly reduced compared to untreated roots.

During the course of this research, experiments were performed to obtain information on the effect of inoculating, injuring, and washing roots on fungus infection and respiration rate. Injury was essential for fungus infection. Many uninjured roots were inoculated, but none became infected. Inoculation was necessary for high levels of infection on washed roots but was not necessary when using unwashed roots. This indicated an abundance of inoculum present in soil adhering to unwashed roots.

Conclusions

The results of these experiments indicate that within a period of one month the respiration rate of stored sugarbeet roots will double if approximately 20 percent of their surface area is infected by fungi. They also indicate there will be over a three-fold increase in reducing sugars with similar amounts of infection.

A spray application of benomyl, or thiabendazole, at a concentration of 500 ppm will prevent infection by Penicillium and Botrytis of injured sugarbeet roots during the initial storage period.

Root injury before storage is probably the most significant factor determining the extent of fungus infection. There is probably sufficient fungus inoculum, particularly of Penicillium, in soil adhering to roots to initiate infection when conditions are favorable in stored roots.

Literature Cited

(1) Miller, G. L. 1959. Use of dinitrosalicylic acid reagent for determination of reducing sugar. Anal. Chem. 31: 426.

Table 1. Fungicides Tested as a Control for *Penicillium* and *Botrytis*

Benlate (Benomyl)	OAC 5
Botran	OAC 258
Bravo 6F	Pyrocatechol
Dowicide A	Steri-Seal "D# (SOPP)
Dowicide 1	Steri-Seal D-D-400
Fisons NC16598	Terraclor (PCNB)
Hydrogen peroxide	Terrazole
Mertect (Thiabendazole)	Zinc Omadine

Table 2. Inhibition of fungus growth on agar medium by four fungicides

		Inhibition in percent of control for each concentration		
Fungus	Fungicide	100ppm*	1,000ppm	10,000ppm
Botrytis	Benomyl	44	51	56
	Thiabendazole	27	54	57
	SOPP	0	23	54
	PCNB	13	18	26
Penicillium	Benomyl	21	31	49
	Thiabendazole	0	27	41
	SOPP	0	14	33
	PCNB	0	7	9

* Concentrations were adjusted to comparable amounts of active ingredient for each fungicide.

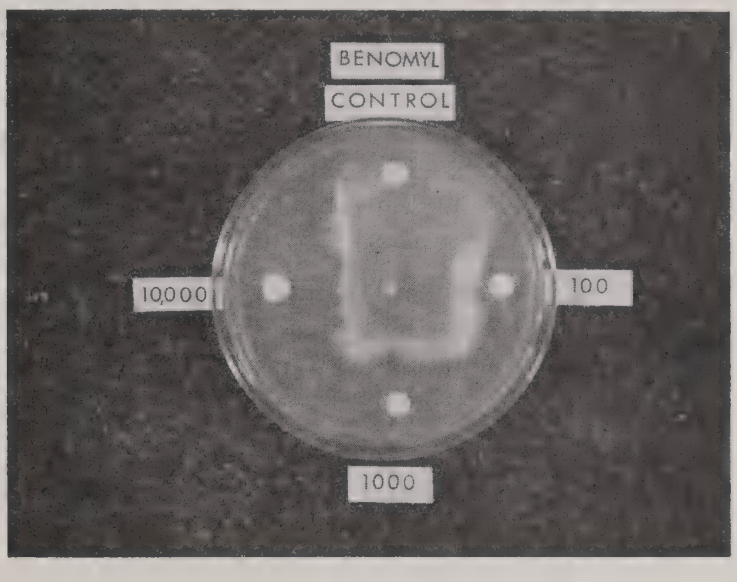

Figure 1. Inhibition of Botrytis growth on agar by different concentrations of fungicide.

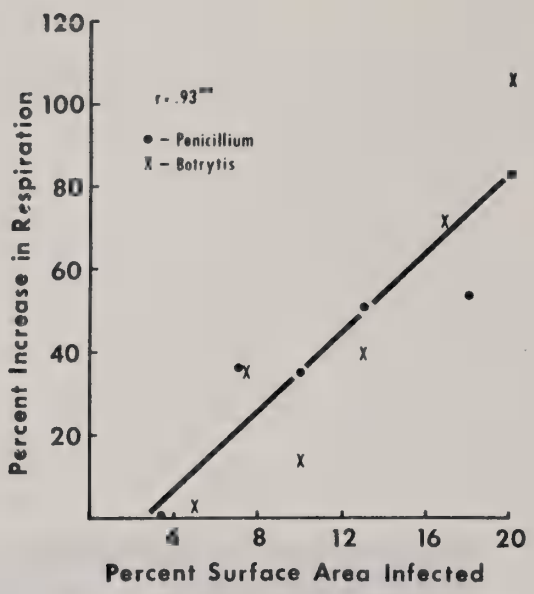

Figure 2. Relationship of root surface area infected to increase in respiration rate.

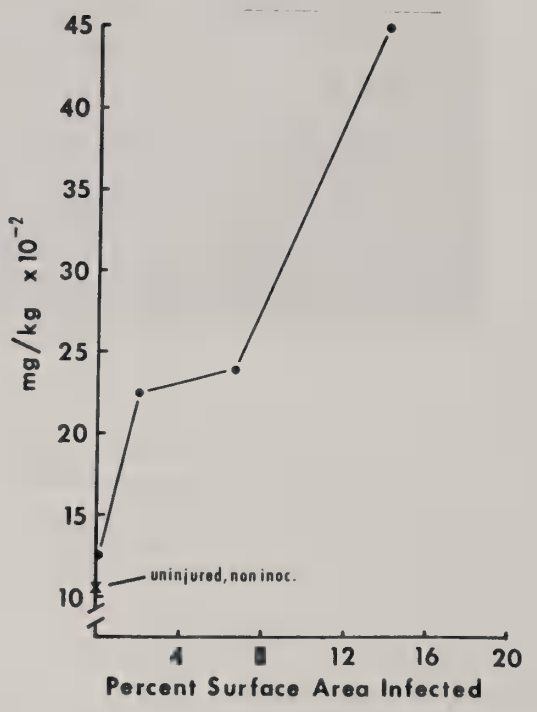

Figure 3. Relationship of root surface area infected to increase in reducing sugars accumulated.

THE POTENTIAL OF BREEDING FOR STORAGE RESPIRATION RATE IN SUGAR BEETS

J. C. Theurer, R. E. Wyse, D. L. Doney

Approximately 60-75 percent of the sugarbeet crop in the northern growing regions of the United States is stored for a few days to 150 days prior to processing. During this storage period, processing quality declines as a result of sucrose loss by respiration, the accumulation of impurities that increase factory load, and from rotting and physical deterioration of beets. About 540 million pounds of sugar are lost due to storage each year, which amounts to approximately 108 million dollars a year.

Respiration accounts for 70 percent of the sugar loss under the best storage conditions. Thus, decreasing respiration in storage piles is of prime importance as a solution for this problem.

Nelson and Woods (3) and Stout (4) observed differences in respiration rate of varieties as early as 1950 and suggested that selection for low respiration rate was possible. However, little effort has been made to substantiate the possibility of decreasing storage losses by genetic means.

We have found a highly significant linear relationship of sucrose loss and respiration rate. Twenty-one hybrids and inbreds stored for 160 days at 5 C (40 F.) gave a correlation coefficient of 0.85. (See Fig. 1, page B60, 1974 Research Report.)

A group of hybrids evaluated in 1973 and 1974 tended to show an alignment with their lower respiring inbred parent. The ranking of the hybrids over a two-year period demonstrated that the respiration rate relative to variety tends to be quite consistent from year to year. (See Table 1, page B71, 1974 Research Report.)

Materials and Methods

In 1974, a diallel-cross experiment was initiated to confirm results of previous years and to gain further insight into the inheritance and breeding potential of low respiration rate. This experiment was repeated in 1975.

Eight inbreds and their diallel F_1 crosses were planted in 1974 in two-row plots, 12 meters (40 ft.) long in six replicates of a split-plot experiment. This year, the diallel consisted of nine inbreds and their F_1 hybrids in all combinations. The FC506 (F6) inbred and hybrids were planned for use but not included in the 1974 test because of insufficient seed of some of the hybrids. Conventional thinning left plants 30 cm (8-12 inches) apart in 56 cm (22-inch) rows.

The inbreds used in the diallel were selected for their genetic diversity and not selected for respiration characteristics prior to the experiment.

At harvest, the beets were flailed twice and left untopped. Ten sound beets were selected from each replicate for storage. Another ten beets from each row in the plot were sampled for sugar content, and root weight was determined from all of the beets of the plot, including samples. Data on yield and sugar percent were given previously in Test 1 of the variety trials in this report.

The ten-beet samples selected for storage were stored at 5 C (40 F.) in a walk-in cooler. After 30 days' storage, the roots were evaluated for respiration, using an automated system for determining carbon dioxide gas exchange. (See 1973 Research Report, page B78.)

The data was statistically analyzed according to Griffing's (2) method 2 for parents and their F_1 hybrids, excluding reciprocal crosses.

Results and Discussion

The diallel respiration rates and combining ability F ratios are given in Tables 1 and 2 for 1974 and 1975, respectively. In general, the respiration rates were higher in 1975 than they were in 1974. After 30 days' storage, most of the results for the two years were quite similar. However, some seasonal interactions were observed. There were greater differences between the inbreds and some of the hybrids in 1975 than observed in 1974. L53 was the inbred having the most rapid respiration both years. In 1975, it was significantly higher than any of the other inbreds tested. However, in 1974, only L29 was significantly lower than L53. Averaged over both years, L29 was the lowest respiring inbred. A5 had the lowest reading in 1975 but was one of the higher respiring lines in 1974. We do not have a ready explanation for this seasonal interaction.

The F ratios for general and specific combining ability were both highly significant each year. This indicates that respiration rate is conditioned by both additive and non-additive gene action. Comparison between years also shows a close consistency in the F ratios for both general and specific combining ability.

With few exceptions (only five in 1975), the hybrids consistently were lower in respiration rate than either of their parent inbreds. The mean respiration rates combined over all crosses for each inbred gave significantly lower respiration rates than the mean of the mid-parent values each year (Table 3). This demonstration of heterosis was evident for hybrids of each inbred in the experiment. There were also significant differences in the magnitude of heterosis for each line. Although L53 had the highest respiration rate of the inbreds in the test, it also was the inbred showing the greatest heterosis for low respiration rate in hybrid combinations.

We calculated the respiration rate after 180 days' storage in 1974 and found similar trends to the 30-day storage, but differences were not as pronounced. At this reading, the respiration rate was highly correlated with the percentage of mold-free roots (r=-.73). The highest respiring lines were also those with the highest percentage of infected roots. Of interest was the fact that mold growth in the inbreds was higher than in the hybrids. This may be due to the vigor of the hybrids.

Mitochondrial efficiency and growth studies conducted at our laboratory (1) complement the hybrid versus inbred data of this diallel study on storage respiration rate. In all cases, hybrids had higher ADP:O ratios than their inbred parents, suggesting that hybrids were more efficient than inbreds in mitochondrial respiration. Thus, less sucrose will be needed to provide the ATP necessary for maintaining cellular integrity.

In sugarbeet production, we are always concerned with the effect of selection for any character and the resultant influence on root weight and sucrose content. Correlations for yield were significant and negative (r:-.70**) indicating that the higher yielding lines tend to have the lower respiration rates. Little, if any, association was noted when respiration rate and sucrose content were correlated (r=-.40). These results demonstrate only a favorable response for sugar production if the breeder were to select for low respiration rate.

Since the inbreds in this diallel were not selected for their respiration characteristics, the differences between inbreds and hybrids are not indicative of the full potential improvement to be gained by selection for respiration rate. The data do substantiate that selection for low respiration can be made, and that low respiring varieties can be developed as a means of decreasing the extensive sugar loss in storage piles.

Summary

1. Two years' data demonstrate that selection to reduce respiration rate and storage losses can be effective in sugarbeets.

2. Heterosis was observed for low respiration rate both years.

3. Both additive and non-additive gene action control respiration rate.

4. Selection for respiration rate should not adversely affect root yield or sucrose content.

Literature Cited

(1) Doney, D. L., R. E. Wyse, and J. C. Theurer. 1975. Mitochondrial effeciency and growth rate in sugarbeet. Crop Science 15:5-7.

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(3) Nelson, R. T. and R. R. Wood. 1950. Respiration and spoilage studies employing a modification of method developed by Stout and Fort. Proc. Amer. Soc. Sugar Beet Technol. 6:660-663.

(4) Stout, Myron. 1954. Sugar beet evaluation. Determining respiration rate and sampling for chemical analysis of sugar beets. Agric. and Food Chem. 2:1324-1328.

Table 1. Diallel cross respiration dates for inbreds and hybrids and combining ability F ratios, 1974.

Females	Males							
	L29	L33	L53	A1	A4	A5	E1	F4
					Mg CO_2/kg/hr			
L29	8.61[1/]	8.45	6.26	6.23	6.91	6.40	7.22	6.32
L33		9.93	6.45	7.73	6.88	6.92	7.66	8.18
L53			10.52	6.72	6.62	7.02	8.27	6.63
A1				9.09	8.82	7.07	7.65	8.01
A4					9.91	6.05	7.93	7.70
A5						10.13	7.05	6.90
E1							9.26	8.12
F4								10.31

LSD .05 (between individual hybrid and/or parents)= 1.50

General Combining Ability F Ratios = 6.66**
Specific Combining Ability F Ratios = 5.50**

** Significant at p = .01

1/ Multiplying times 0.0312 converts to lbs. sucrose/ton/day

Table 2. Diallel cross respiration rates for inbreds and hybrids and combining ability F ratios, 1975.

Females	Males								
	L29	L33	L53	A1	A4	A5	E1	F4	F6
					Mg CO_2/kg/hr				
L29	10.58	11.98	11.33	10.66	10.47	9.98	10.18	10.32	12.48
L33		16.13	9.38	10.95	10.98	10.13	11.25	10.38	10.90
L53			20.03	9.50	10.10	9.70	9.28	9.87	10.05
A1				14.42	11.10	10.02	11.25	10.73	11.77
A4					15.15	9.65	10.70	9.42	9.98
A5						10.07	10.20	9.13	10.32
E1							15.19	10.85	11.02
F4								13.02	11.88
F6									13.23

LSD .05 (between individual hybrid and/or parents) = 1.95

General Combining Ability F Ratios = 6.64**
Specific Combining Ability F Ratios = 6.82**

** Significant at p = .01

Table 3. Inbred mid-parent means, hybrid means, and heterosis for respiration rate, 1974 and 1975.

	1974 Means			1975 Means		
	Inbred Mid-Parent	Hybrid	Heterosis	Inbred Mid-Parent	Hybrid	Heterosis
L29	9.24	6.83	2.41	12.62	10.93	1.69
L33	9.81	7.47	2.34	15.05	10.74	4.31
L53	10.06	6.86	3.20	16.75	9.90	6.85
A1	9.45	7.46	1.99	14.30	10.75	3.55
A4	9.80	7.27	2.53	14.62	10.30	4.32
A5	9.90	6.77	3.13	12.39	9.89	2.50
E1	9.52	7.70	1.82	14.63	10.59	4.04
F4	9.97	7.41	2.56	13.69	10.32	3.37
F6	--	--	--	13.78	11.05	2.73
LSD	0.40	0.51	0.48	0.48	0.68	0.56

EFFECT OF LOW TEMPERATURE AND FLUCTUATING TEMPERATURES ON SUCROSE LOSSES IN STORAGE

Roger Wyse

The optimum temperature for sugarbeet storage and the magnitude of fluctuation in this temperature which can be tolerated are important factors to be considered when designing permanent and semi-permanent sugarbeet storage structures. Determining an optimum storage temperature for sugarbeet is difficult. Lower temperatures will substantially reduce respiration rates (1, 2), but temperatures below 35 degrees will normally result in increased raffinose accumulation. The cooling and temperature control of beet storage piles is normally accomplished by the use of ventilation fans and available cool night air. The result is relatively slow cooling coupled with warming and cooling cycles, resulting from changes in the availability of cooling air. The effect of these fluctuations on beet storage life has not been studied. Dilley (2) reported large increases in respiration rates when roots were moved from lower to higher temperatures in the range of 0 to 20 C in short-term experiments. These data indicate that fluctuation in storage temperature may be an important factor in determining the storage life of sugarbeets.

The objective of this study was to determine the effect of fluctuating storage temperatures in the range of -1 to 10 C on respiration rates, sucrose loss, and reducing sugar accumulation during 120 days of storage.

Methods

Roots were machine harvested, hand washed, and sorted into 13 storage treatments, consisting of ten replications of eight roots each. The storage treatments were as follows: storage at a constant 30, 35, 40, 50-55; weekly fluctuations between 30-35, 30-40, 30-50, 35-50, 40-50, or storage at a constant 40 F except for one week per month when the samples were moved to 30, 35, or 50 F.

Each sample was weighed before and after storage and all analyses corrected for weight loss. Sucrose was measured by the cold digestion method and corrected for the presence of raffinose and invert sugars. Raffinose and reducing sugars were determined by paper chromatography and dinitrosalicylic acid, respectively, (3). Respiration rates were determined twice daily with an infrared analyzer and an automated switching system. Although the samples were rotated as described above, due to a lack of respiration sampling capacity at all temperatures, respiration rates were not measured on all samples every week.

Temperatures causing cellular damage were determined by exposing 2 mm x 10 mm disks to temperatures from 20 to 37 F for two hours. To establish these temperatures, a one-inch thick aluminum plate was constructed with circulation tubes drilled in each end. Coolant at 15 F was circulated through one end and 40 F water through the other. Heat conductance by the aluminum plate thus established a linear temperature gradient over the length of the plate. Root disks were placed directly on the plate, and the actual temperature of the disk was determined using thermocouples.

After exposure, the disks were placed into flasks containing 5 ml of water and held at room temperature for 75 minutes. The carbohydrate content of the solution was then measured, using the anthrone method. Cellular damage was detected as a loss of cellular contents, primarily sucrose.

Results

Results of the respiration study were reported in the 1974 "Bluebook." These results indicated the sensitivity of beet root respiration to temperatures near 30 F and the potential for reducing storage life by exposure to these temperatures.

Figure 1 summarizes the effect of temperature fluctuation on sucrose loss. Sucrose losses were measured polarimetrically with corrections for weight loss and the optical errors induced by raffinose and invert sugars. The temperature fluctuation given is the magnitude of the fluctuation irrespective of the mean treatment temperature. It is readily apparent that losses were minimized when storage temperatures are held constant. Figure 2 summarizes the effect of fluctuating storage temperatures on reducing-sugar accumulation. Reducing-sugar accumulation is also minimized in constant temperature storage.

To determine the most detrimental combinations of temperatures, sucrose loss was plotted against mean treatment temperature (Fig. 3). The solid line represents sucrose losses at constant temperature. If the fluctuating temperature treatments fall above this line, the fluctuating temperature reduced storage life. If fluctuating the temperature had no effect, the point should fall on the same line as the constant temperature treatment. Treatments having 30 F as one temperature all significantly increased sucrose losses, as did the 35-50 treatment. This data substantiates the respiration data which indicated that the beet root is particularly sensitive to temperatures near freezing.

The results of reducing-sugar accumulation are similar to those for sucrose loss (Fig. 4). The solid line connects the constant temperature treatments. Those points below the line represent

fluctuating temperature treatments that significantly depressed the accumulation of reducing-sugars. The same treatments which increased sucrose losses also increased reducing-sugar accumulation.

Freezing-Point Determinations

The amount of carbohydrate released by the disks increased as temperature was decreased (Fig. 5). The cells did not show injury down to 32 F. At 32 F, the first cells began to show damage. At 29 F, cell damage became extensive, and at 26.5 F one-half of the cells were damaged or frozen. All cells were damaged or frozen at 23.5 F.

Discussion

The results indicate reduced storage life, increased sucrose losses, and increased reducing-sugar accumulation when sugarbeet roots are exposed to fluctuating temperatures, or temperatures near 30 F.

Storage between 35 and 40 F appears to be in an optimum temperature range. Fluctuations within this range can be tolerated without increasing sucrose losses. Roots stored at this temperature will also tolerate exposure to brief periods of warmer temperatures with minimal damage.

Irreversible damage, as demonstrated by loss of cellular contents and increased respiration rates, results from exposure to temperature below 29 F.

From a practical standpoint, these results indicate that outside air, or plenum air, below 30 F should not be introduced into a beet storage pile. The only time cooler temperatures would be warranted is when pile temperatures are excessively high, and the losses due to high temperature would offset the reduced storage life induced by excessive cooling. Undoubtedly, the advantages of using 30 F air to cool beets immediately after harvest would outweigh the disadvantages of reduced storage life. When the pile is relatively warm (50-60 F), only those beets within a few feet of the ventilation tubes would be exposed to 30 F air. Therefore, 30 F can be introduced into a storage pile early in the storage period if due caution is observed.

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(1) Barr, C. Guinn, E. M. Mervine, and R. A. Bice. 1940. A preliminary report on the effect of temperature and beet conditions on respiration and loss of sugar from beets in storage. Proc. Amer. Soc. Sugar Beet Technol. Part 1:52-65.

(2) Dilley, David R., Ralph R. Wood, and Phillip Brimhall. 1970. Respiration of sugarbeets following harvest in relation to temperature, mechanical injury, and selected chemical treatments. J. Amer. Soc. Sugar Beet Technol. 15:671-683.

(3) Miller, G. L. 1959. Use of dinitrosalicylic acid reagent for determination of reducing sugar. Anal. Chem. 31:426, 1959.

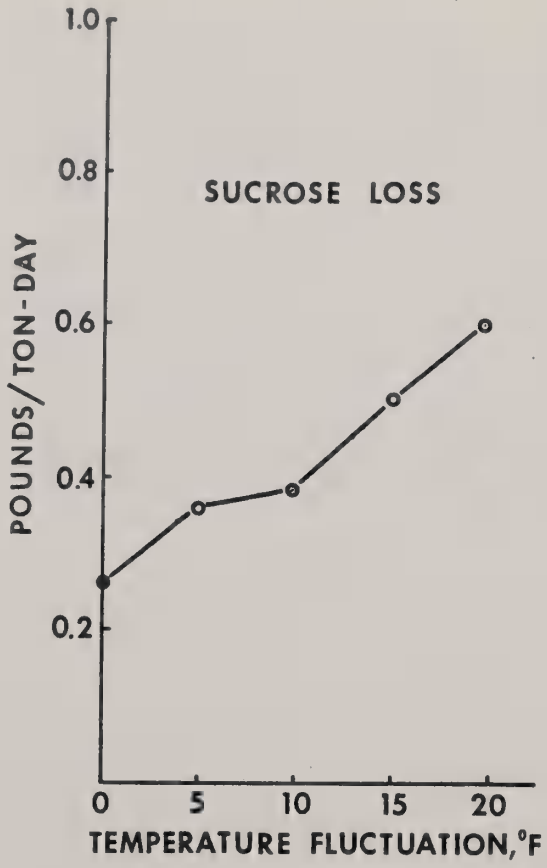

Figure 1. The effect of temperature fluctuations on the loss of sucrose during storage.

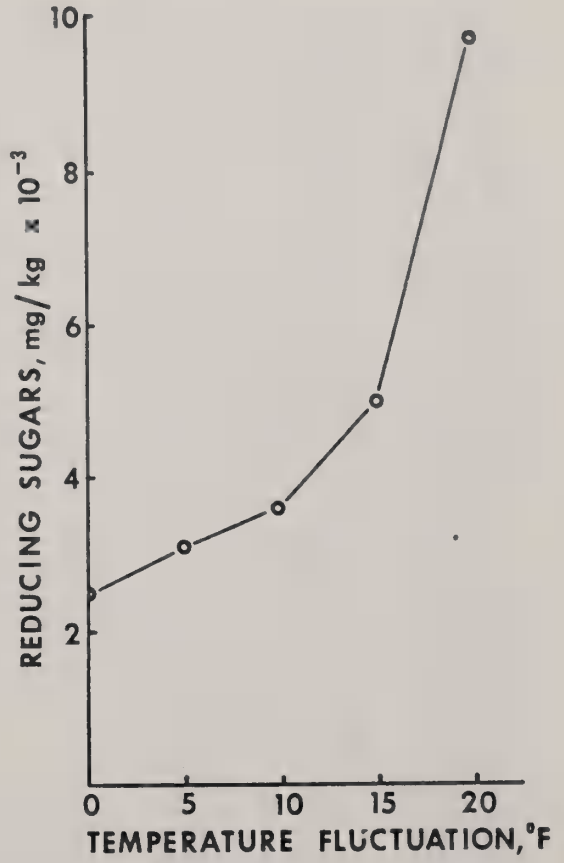

Figure 2. The effect of temperature fluctuations on reducing sugar-accumulation during storage.

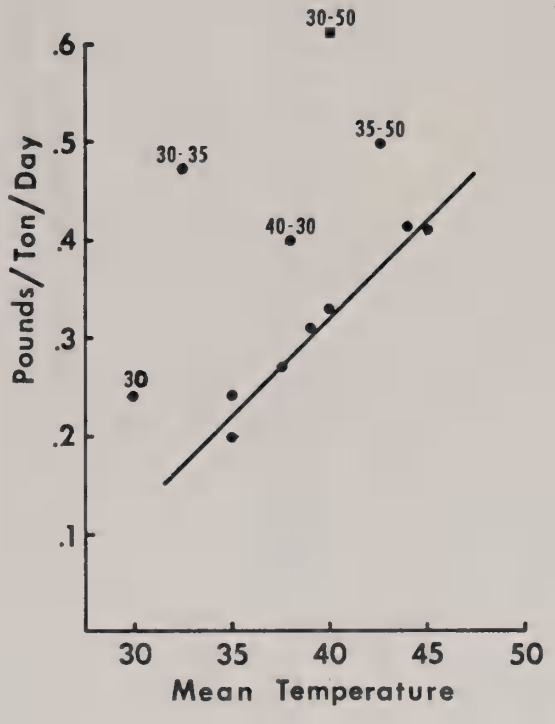

Figure 3. Relationship of sucrose loss and mean treatment temperature. Solid line represents losses at constant temperature.

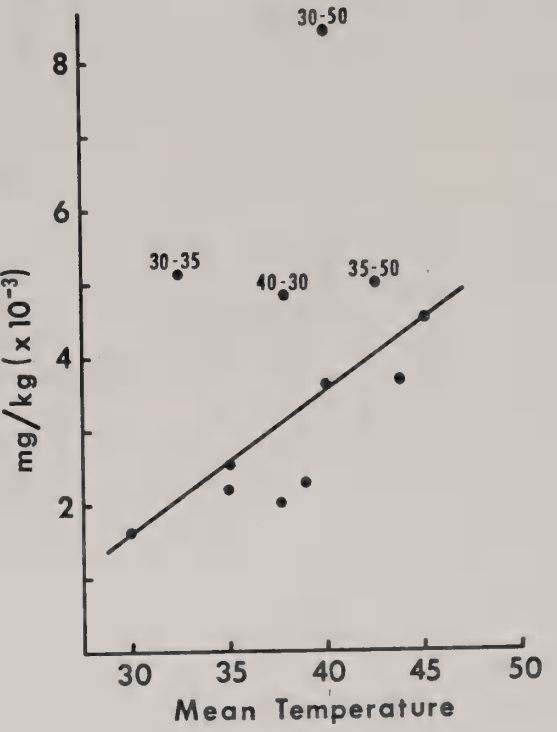

Figure 4. Relationship of reducing-sugar accumulation and mean treatment temperature. Solid line represents accumulation at constant temperature

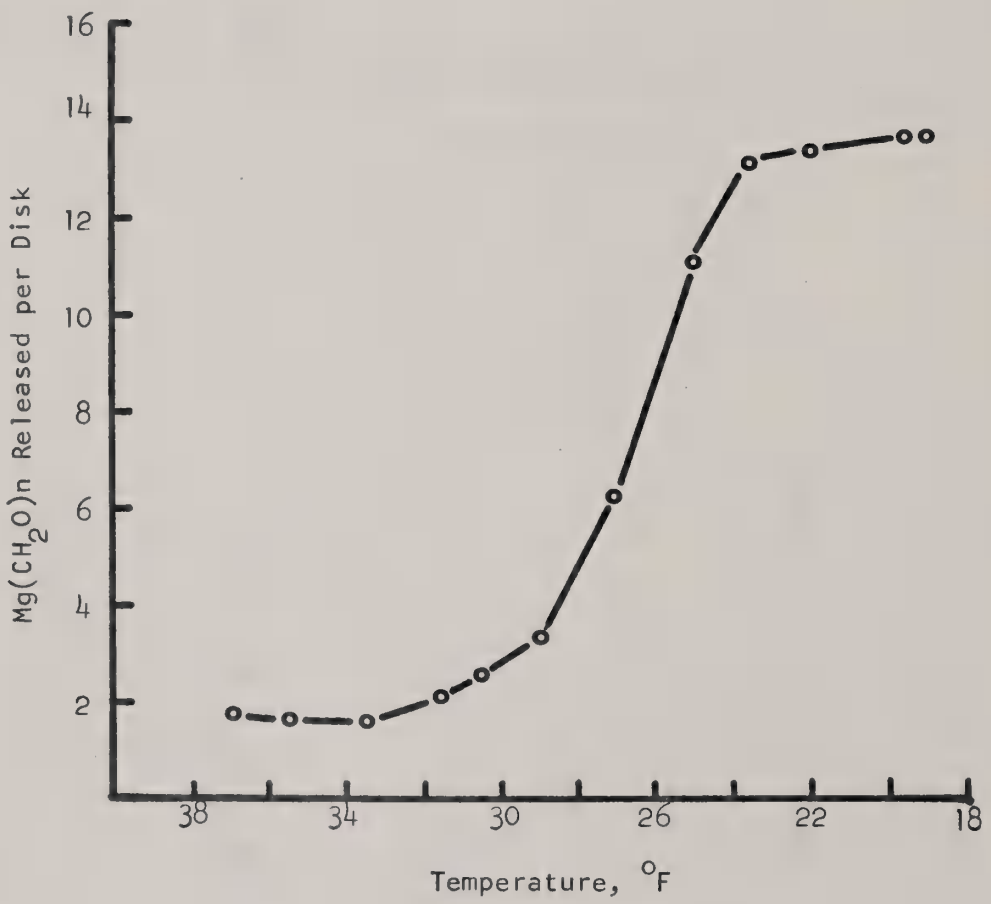

Figure 5. Carbohydrate $(CH_2O)n$ released as a result of exposure to various low temperatures.

A COMPUTER SIMULATION MODEL FOR PREDICTING PILE TEMPERATURES AND SUCROSE LOSSES IN SUGARBEET STORAGE STRUCTURES

Roger Wyse

The development of improved storage structures can greatly reduce sucrose losses through better control of pile environment. However, the proper design and management of these structures is based on an understanding of both the physiological characteristics and the heat transfer properties of the sugarbeet root. The purpose of this study was to develop a computer simulation model capable of predicting pile temperatures and sucrose losses based on known physiological responses immediately after harvest and the heat transfer characteristics of the sugarbeet pile.

Methods

The cooling characteristics of a deep bed of sugarbeets were determined. Approximately one ton of roots was placed in an insulated column 36 inches square. Cooling air was passed through the 8-foot high column at controlled temperatures and rates. The temperature of roots and air was monitored with thermocouples at approximately 1-foot levels throughout the column. The heat transfer coefficients were then calculated from the data generated by several heating and cooling cycles. The thermal behavior and the known physiological responses of the beet root were then incorporated into a model which was programmed for use on the Burroughs 7400 computer.

The model inputs are respiration rate, initial beet temperature, temperature of the ventilation air, and ventilation rate in CFM/ton. From these inputs the model will predict pile temperatures at 2-foot intervals within the pile and the daily mean sucrose loss within the pile.

Results

The model is still preliminary and is currently being evaluated for its ability to predict the behavior of actual commercial storage piles. The results appear to follow actual pile cooling rates very closely. Although the model does not give absolute values at this time, it gives valid relative comparisons of such parameters as respiration rates and ventilation rates.

In Figure 1 the effect of ventilation rates on pile cooling are compared. The mean pile temperatures shown were calculated from the temperatures at 2-foot intervals in a 20-foot high pile. Therefore, the mean values do not indicate the temperature spread within the pile. In this example, it was assumed that the roots (initial beet temperature was 55 F) were topped and that 10 hours of 40 F and 14

hours of 50 F air were available for ventilation each day. It is readily apparent that 10 CFM/ton is not sufficient to control pile temperature given the cooling air available. Both 20 and 40 CFM per ton caused the pile temperature to equilibrate with the ventilation air after about four days.

Adding refrigerated air for the first 24 hours after piling did not improve cooling rates when 10 CFM/ton was used. However, at 20 and 40 CFM/ton, mean pile temperature decreased by 2 and 5 F, respectively.

The advantage of increased ventilation rates is not only to reduce the mean pile temperature but also to reduce the temperature gradient within the pile (Table 1). Increasing the flow from 10 to 20 CFM/ton reduced the temperature at the 4-foot depth by 18 F after seven days. However, increasing the flow to 40 CFM had little additional advantage.

Table 1. Root temperatures at the 4-foot depth after seven days of cooling at three ventilation rates.

Ventilation rate, CFM/ton	Temperature, ^{o}F
10	69
20	51
40	47

These comparisons indicate that 10 CFM/ton is a marginal flow rate for controlling pile temperatures and that increasing flow rates during the initial cooling period should afford considerable cooling advantage. However, at high flow rates, it may be necessary to add water to the air stream to prevent excessive desiccation.

It was evident from the temperature curves of the beet at the 1-foot depth in the experiment pile that evaporative cooling was an important factor in determining the ventilation air temperature above this depth (Fig. 2). The ventilation air temperature was 40 F but one foot above the ventilation tube the air temperature was reduced to 35 F or 80 percent of the wet-bulb temperature. Therefore, rapid cooling was occurring at the expense of evaporative water loss in the beets near the ventilation tube. Most of the desiccation occurred within two feet of the ventilation tube (Fig. 3), while very little water loss occurred above this level.

These data indicate that the addition of free water to the beet pile, or humidifying the ventilation air, will not improve cooling rates by reducing ventilation air temperatures but will only prevent desiccation of the roots near the ventilation tubes.

The model will not only evaluate environmental parameters but also changes in the physiological characteristics of the beet root. For example, removing the crown tissue from the beet root greatly increases respiration rates during the first two days after harvest compared to an untopped root (Fig. 4). The model will predict the effect of this high initial respiration rate on pile temperature and sucrose loss during the first week of storage.

Assuming a ventilation rate of 10 CFM/ton for 12 hours per day with 40 F air, the predicted pile temperatures for beets entering the pile at 60 F and 50 F are given in Figure 5. In both cases, the pile temperature could not be controlled during the first week of storage if the roots were topped. However, 10 CFM/ton air at 40 F for 12 hours per day would control or reduce pile temperatures if the roots were not topped. The effect of the higher respiration rates and higher pile temperatures on sucrose losses during the first week of storage is given in Table 2.

Table 2. Effect of topping on sucrose losses during the first week of storage.

Initial Beet Temperature	Losses	
	Topped	Untopped
	lbs/ton	
50 F	5.3	2.5
60 F	7.6	5.3

Topping doubled the sucrose loss during the first week of storage at both 60 and 50 F initial beet temperatures. Note also the savings of 2.3 and 0.8 lbs/ton for the topped and untopped roots, respectively, if the initial beet temperature was reduced 10 F from 60 to 50.

Conclusions

The model allows meaningful evaluations to be made of pile management practices in terms of pile temperature and sucrose loss. The model can be used to make relative comparisons but must be tested on a commercial pile before it can be used to predict absolute losses.

The model should be an important aid in the design of structures and the development of effective storage practices.

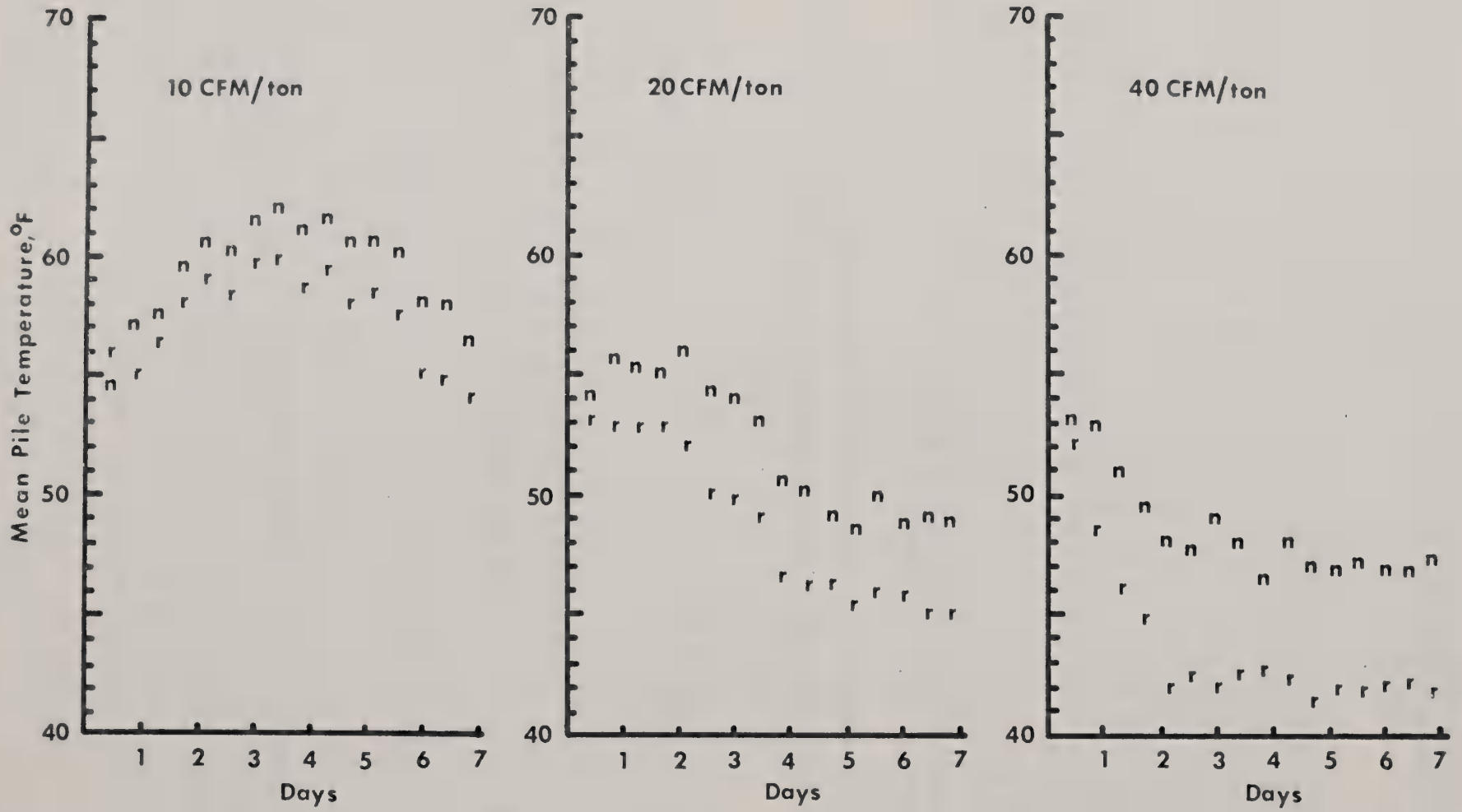

Figure 1. Effect of ventilation rates and refrigeration on mean pile temperatures during the first week of storage. Ventilation air temperatures were 40 F for 10 hours and 50 F for 14 hours. Initial beet temperature was 55 F. Refrigeration was for 24 hours at 35 F during the first 24 hours after harvest. N = normal air, r = refrigerated air.

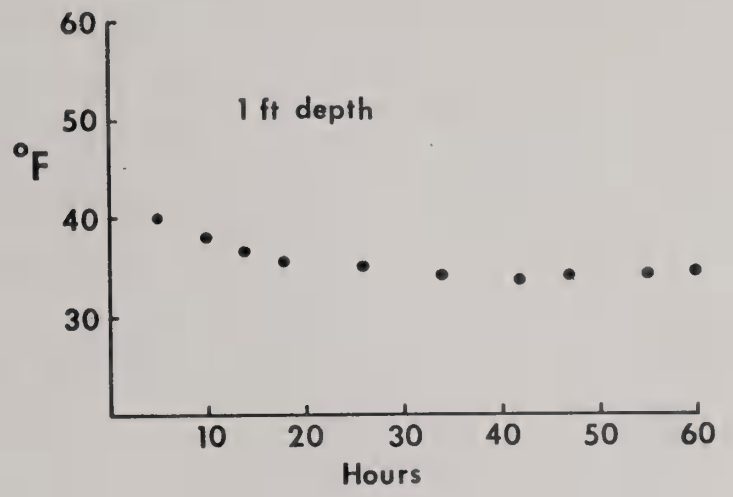

Figure 2. Temperature of the beets one foot above the ventilation tube. Ventilation air temperature was 40 F.

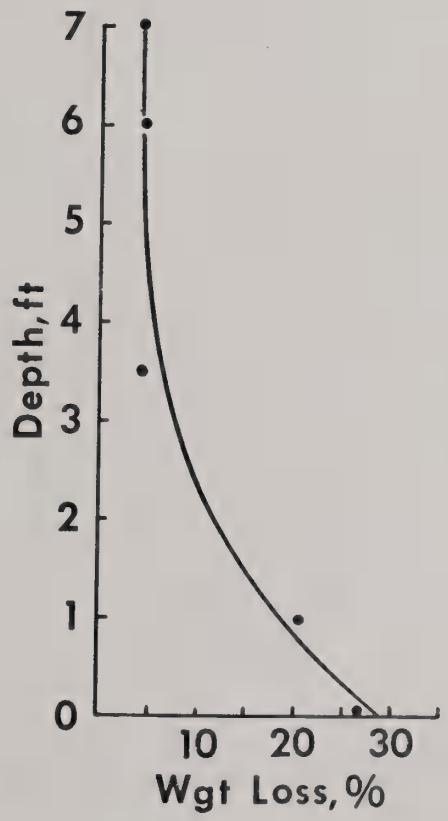

Figure 3. Desiccation levels above ventilation tubes.

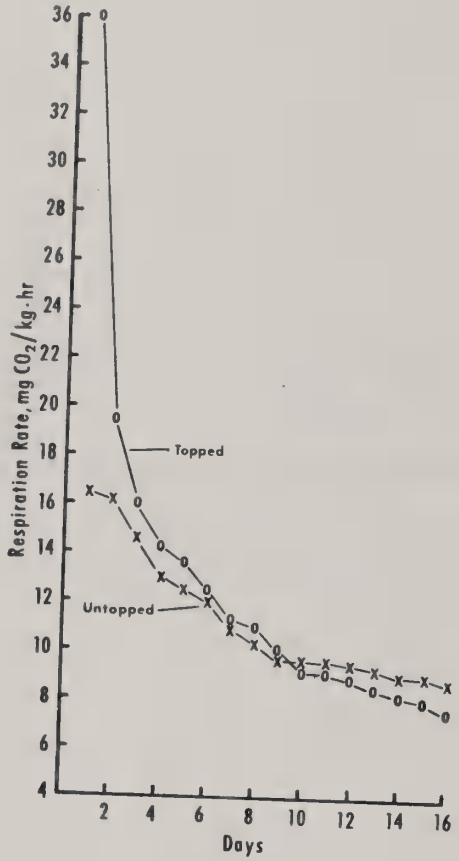

Figure 4. Effect of topping on the respiration rate of sugar-beet roots immediately after harvest.

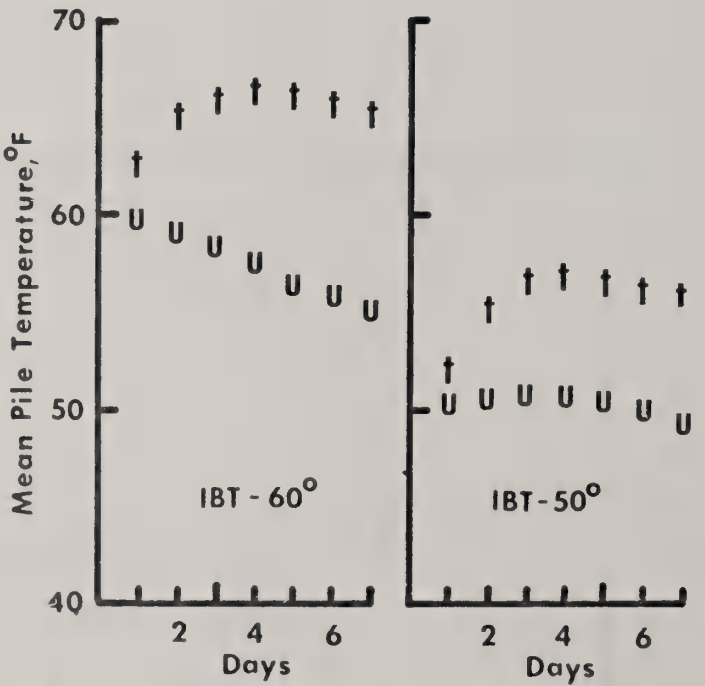

Figure 5. Predicted mean pile temperatures for topped and untopped beets assuming initial root temperatures of 50 and 60 F. Ventilation conditions were 10 CFM/ton of 40 F air for 12 hours per day. T = topped, u = untopped.

SUGARBEET RESEARCH

1975 Report

Section C

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This research was supported in part by funds provided through the Beet Sugar Development Foundation (Projects 20, 25, and 50).

CONTENTS

Page

ABSTRACTS OF PAPERS PUBLISHED OR APPROVED FOR PUBLICATION, 1975

HECKER, R. J. and E. G. RUPPEL. Polyploid and maternal effects on rhizoctonia root rot resistance in sugarbeet. Accepted for publication in EUPHYTICA.

Three sugarbeet breeding lines partially resistant to the root-rotting fungus, *Rhizoctonia solani*, were converted to the tetraploid condition without selection. These three diploid and tetraploid lines were crossed with three diploid male-sterile lines to produce equivalent diploid and triploid hybrids. The triploid hybrids were significantly more resistant to *Rhizoctonia* than were the diploid hybrids. However, the tetraploid resistant lines were no different than their diploid equivalent lines. Reciprocal crosses provided no evidence of maternal effect on resistance. Cytoplasm that included the male-sterility factor had no influence on resistance. Triploid hybrids, where the resistant parent is tetraploid, should be advantageous in the breeding of rhizoctonia-resistant hybrid varieties.

HECKER, R. J., E. G. RUPPEL, G. W. MAAG, and D. M. RASMUSON. Amino acids associated with cercospora leaf spot resistance in sugarbeet. Phytopath. Z. 82:175-181. 1975.

Sugarbeets (*Beta vulgaris* L.) from a field-grown disease-free experiment were used to determine whether any naturally occurring amino acids in beet leaves were associated with resistance to *Cercospora* leaf spot caused by *Cercospora beticola* Sacc. Multivariate and discriminant analyses of the data were used to determine if the relative quantities of particular amino acids could be used to classify cultivars as resistant or susceptible.

Twenty-two amino acids and two amides were determined quantitatively by automated analysis of leaves collected on three sampling dates from six sugarbeet cultivars. The six cultivars had a wide range of resistance to *C. beticola*. Results showed the aromatic amino acid, L-3,4-dihydroxyphenylalanine (DOPA), to be significantly higher in the resistant cultivars at all sampling dates. L-glutamic acid was significantly higher in the susceptible cultivars. Use of a linear summary variate based on the DOPA and glutamic acid data showed the probability of correctly classifying a cultivar as resistant or susceptible was 0.81. The mode of action of the amino acids in the disease resistance mechanism was not determined.

MARTIN, S. S. Cercosporin, a phytotoxic pigment, isolated from leaves of Beta vulgaris infected by the fungus Cercospora beticola. Approved by ARS for publication in Phytochemistry.

The phytotoxic pigment cercosporin [1,12-bis(2-hydroxypropyl)-2,11-dimethoxy-6,7-methylenedioxy-4,9-dihydroxyperylene-3,10-quinone] was isolated from *Cercospora beticola*-infected leaves of sugarbeet cv. R & G Pioneer. Necrotic, heavily lesioned regions of infected leaves were extracted with ether and the extract filtered, washed, dried, and evaporated to dryness. The residue was eluted in a small volume of

acetone and paper chromatographed on Whatman No. 1 using the organic phase of benzene-glacial acetic acid-water (2:1:1 v/v). From multiple chromatograms, orange-pink spots at R_f ca. 0.70 were eluted with absolute EtOH, combined and evaporated. The isolated pigment was characterized by UV and IR spectroscopy in EtOH and CCl_4, respectively, and by TLC in three solvent systems, and was identical with cercosporin isolated from agar cultures of the fungus.

RUPPEL, E. G., L. M. BURTCH, and A. D. JENKINS. Benomyl-tolerant strains of Cercospora beticola from Arizona. Approved by ARS for publication in Plant Dis. Reptr.

After a 3- to 4-year program of leaf spot control with benomyl in the Willcox area of Arizona, effective control was no longer obtained. Single-spore isolates from *Cercospora*-infected sugarbeets grown near Willcox were all highly tolerant to benomyl in vitro. It is recommended that the use of benzimidazole fungicides be discontinued in areas where tolerant strains have developed.

RUPPEL, E. G., M. D. HARRISON, and A. KENT NIELSON. Occurrence and cause of bacterial vascular necrosis and soft rot of sugarbeet in Washington. Plant Dis. Reptr. 59:837-840. 1975.

Bacterial vascular necrosis and soft rot (BVN-R) of sugarbeet occurred in the Moses Lake area of Washington in 1974. This is the first report of the disease outside of California. Biochemical, physiological, and pathogenicity tests showed that the causal bacterium was *Erwinia carotovora*, with properties similar to *E. carotovora* var. *atroseptica*. Washington and California isolates were similar in all tests. Isolates from California and Washington infected potato stems; however, authentic strains of *E. carotovora* var. *atroseptica*, *E. carotovora* var. *carotovora*, and *E. chrysanthemi* were nonpathogenic in sugarbeet.

BVN-R was not associated with rotation histories or most cultural practices used in affected fields. In addition, there was no apparent relationship between disease incidence and soil type, pesticide and fertilizer programs, or sugarbeet cultivars. Disease occurred in low poorly drained areas of fields and in furrow-irrigated, but not in sprinkler-irrigated, fields.

Published Papers Abstracted in Sugarbeet Research, 1974 Report

HECKER, R. J. and E. G. RUPPEL. Inheritance of resistance to Rhizoctonia root rot in sugarbeet. Crops Sci. 15:487-490. 1975.

HECKER, R. J. and J. O. GASKILL. Plastic isolation chambers for sugarbeet seed production. J. Amer. Soc. Sugar Beet Technol. 18:264-268. 1975.

HECKER, R. J. and G. A. SMITH. Tests of granular ethephon as a male gametocide on sugarbeet. Can. J. Plant Sci. 55:655-656. 1975.

MAAG, G. W. and G. H. SISLER. False polarization: Quantitation and characterization in sugarbeet processing juices. J. Amer. Soc. Sugar Beet Technol. 18:257-263. 1975.

RUPPEL, E. G. Biology of benomyl-tolerant strains of Cercospora beticola from sugar beet. Phytopathology 65:785-789. 1975.

RUPPEL, E. G. A cultural variant of a benomyl-tolerant strain of Cercospora beticola. Phytopathology 65:734-735. 1975.

RUPPEL, E. G., F. J. HILLS, and D. L. MUMFORD. Epidemiological observations on the sugarbeet powdery mildew epiphytotic in western U.S.A. in 1974. Plant Dis. Reptr. 59:283-286. 1975.

RHIZOCTONIA INVESTIGATIONS, 1975

Rhizoctonia Resistance Breeding Research, 1975.--R. J. Hecker and E. G. Ruppel.

Field experiments related to our program of breeding for rhizoctonia root rot resistance in sugarbeet were conducted on our BSDF-leased farm where we also conduct our cercospora leaf spot field research. This was the third crop year of the five year lease on the farm.

Our rhizoctonia root rot epidemic in 1975 was excellent (severe). Except for the selection areas which were rosette-inoculated, the entire field was broadcast-inoculated with a tractor mounted Eze-Flo four-row applicator. The dry, ground barley-grain inoculum of Rhizoctonia solani (isolate R-9) was broadcast in a band over each row at a rate of 9.4 grams per 20 foot of row in a split application with opposite directions of travel for each application. One-row plots 20 feet long and 22 inches apart were planted May 15. Thinning was done between June 26 and July 2, and the experiments were inoculated July 18. The roots were lifted and individually rated for severity of root rot September 22 through 25. The disease index (DI) ratings were based on a scale of 0 to 7 (0 = no evidence of infection, 7 = dead). The percentage of healthy roots (ratings 0 and 1 combined) was also calculated. We consider the disease index to be the best measure of resistance; however, percentage healthy roots does provide a better concept of the proportion of essentially healthy roots among the lines tested.

We are continuing to use both recurrent selection and mass selection in our breeding program for rhizoctonia root rot resistance. Primary emphasis has been on development of resistant lines as potential pollinators. All rhizoctonia resistant breeding lines released through the BSDF to date have been pollen fertile multigerm lines. However, we have crossed these resistant lines with type O monogerm materials and have backcrossed and selected in them. We expect, in the future, to be able to make available type O monogerm resistant breeding lines. Combining ability evaluations of all our breeding lines are limited, and provide us only limited opportunity for combining ability evaluation and improvement.

In the rhizoctonia resistance evaluation of many different sugarbeet lines over many years, we have never found a significant amount of resistance in unselected lines. The only significant amount of resistance apparently available in sugarbeet is that which has been accumulated by selection and breeding specifically for rhizoctonia resistance. From crosses of susceptible X resistant lines we find the hybrids usually show partial dominance for resistance. This partial dominance for resistance makes it appear that resistance in only the pollinator parent of hybrids may be adequate for control of rhizoctonia root rot under commercial production conditions.

In our 1974 report, we presented data demonstrating a dosage effect for resistance in triploid hybrids of diploid susceptible X tetraploid resistant lines. This dosage effect coupled with partial dominance for resistance indicates that triploid hybrids resulting from a tetraploid resistant pollinator may have considerable promise in rhizoctonia-prone production areas, provided acceptable combining ability is present or can be developed in the rhizoctonia resistant lines. We have developed tetraploids of several of our more rhizoctonia resistant lines and will soon be making this germplasm available through the BSDF.

Evaluation of Breeding Lines for Rhizoctonia Resistance.--R. J. Hecker and E. G. Ruppel.

Each year we evaluate for rhizoctonia resistance various breeding lines and other lines of interest. These evaluations for 1975 are listed below in Tables 1 and 2.

Multigerm breeding lines which have potential as pollinators in hybrids continue to show improved resistance with continued selection and breeding. Under the very severe infection in 1975, lines derived from FC 701, FC 702, and FC 703 are among those of greatest resistance. It is interesting, however, that the two most resistant lines in the test (although not significantly different than others) were a line resulting from crosses of leaf spot-curly top resistant monogerm lines with FC 701 and from a line selected for *Phoma betae* resistance in FC 701/4. This latter line was selected and developed by W. M. Bugbee in Fargo in his research program on improvement of storage rot resistance. In general, the multigerm

lines have had more selection and breeding for resistance than those which contain some monogerm germplasm. Therefore, the multigerms have the greatest potential at this time for potential use as pollinators in experimental hybrids. Entry 966 (Table 1) is destined for release through the BSDF. It should have greater genetic diversity than most of the other multigerm resistant populations since it was developed from the interpopulation of five genetically diverse lines, each of which had some rhizoctonia resistance. The resistance of this line (DI = 3.8) needs further improvement, but the population does have potential for simultaneous improvement in both rhizoctonia resistance and combining ability. Entry 968 (Table 1) should have considerable potential since it is quite resistant (DI = 1.7) and is segregating for monogerm and type O. Sublines from this synthetic could be used either on the pollinator or female side of experimental hybrids.

Previous experiments and data in a succeeding section of this report have rather consistently shown partial dominance for resistance. We feel that rhizoctonia resistance in only the pollinator of 3 or 4-way hybrid varieties may be adequate to prevent significant losses to rhizoctonia root rot under natural infection. Hence, we have not made a special effort to isolate type O resistant lines or to develop cytoplasmic male sterile resistant lines; however, entry 968 does have potential for extraction of type O lines from which CMS equivalents could be developed. In addition, this particular synthetic should have modest levels of both leaf spot and curly top resistance.

In Table 2 there are tabulated a number of miscellaneous lines many of which are commercial hybrid varieties. The commercial varieties tested represent well over half of the total sugarbeet production in the U.S. Without exception, these hybrids are highly susceptible to rhizoctonia root rot. This is true in all sugarbeet germplasm that we have tested over the years. We have not found a single sugarbeet line with significant resistance unless it had some history of selection or crossing with our resistant developments.

Experimental hybrids using some of our resistant breeding lines as pollinators were tested for root yields, sucrose, purity in 1975. The results of these tests are described in another section of this report.

Table 1. Rhizoctonia root rot resistance evaluation of multigerm and monogerm breeding lines for disease index (DI) and % healthy roots in 1975. Means within groups within columns followed by the same letter are not significantly different (P = .05).

Entry no.	Populations and description	DI	% healthy
	Multigerm rhizoctonia resistant breeding lines		
993	7326-1; Fargo Phoma selection from FC 701/4	1.7 a	58 ab
946	FC 701/5; 7 cy. Rhiz. selection	1.9 ab	68 a
953	FC 703/1	2.2 ab	51 ab
948	FC 702/5; 7 cy. Rhiz. selection	2.4 abc	51 ab
945	FC 701/5; 6 cy. Rhiz. selection	2.4 abc	45 abc
1003	FC 703; 1st cy. synthetic from greenhouse Rhiz. sel.	2.5 abc	48 abc
950	FC 701/4; 7 cy. Rhiz. selection	2.5 abc	49 abc
984	1st cy. mass sel. for Rhiz. damping off from pool of FC 701/5, FC 702/5, and FC 703	2.6 abc	46 abc
970	Rhiz. selection from pool of GW 674 and C 817 lines	2.7 bc	44 bc
952	FC 702/4	3.2 cd	35 cd
962	FC 801	3.6 d	30 cd
961	FC 703	3.7 d	27 de
965	Synthetic of resist. progeny lines from FC 801	3.8 de	31 cd
966	Synthetic of 5 diverse Rhiz. resist. lines	3.8 de	28 de
963	Synthetic of 2 most Rhiz. resist. Japanese selections	4.1 de	9 f
1002	EL-42; E. Lansing pollinator from FC 702/4 X SP 6822-0	4.6 ef	15 ef
1001	74B4-00; E. Lansing breeding line	5.1 fg	8 f
994	73B5-1; E. Lansing breeding line	5.5 fgh	7 f
1004	732-1; Fargo Phoma selection from FC 702	5.8 gh	8 f
995	73B5-3; E. Lansing breeding line	6.0 h	5 f
	Rhizoctonia resistant breeding lines; mm or seg. mm and TO		
968	Synthetic from FC 701 X (LSR-CTR, mm, TO lines)	1.7 a	68 a
967	Synthetic from BC_1 of (LSR-CTR, mm, TO) X FC 701	4.0 b	19 b
954	Synthetic from BC_1 of (LSR-CTR, mm, TO) X FC 701	4.5 bc	20 b
1000	73B18-25; E. Lansing Mm breeding line	4.6 bc	11 bc
997	73B18-4; E. Lansing mm breeding line	4.7 bc	17 b
996	73B5-25; E. Lansing Mm breeding line	5.4 cd	6 cd
999	73B18-22; E. Lansing Mm breeding line	6.1 de	1 d
998	73B18-11; E. Lansing mm breeding line	6.3 de	1 d
959	US H20 (susc. check)	6.7 e	0 d

Table 2. Rhizoctonia root rot resistance evaluation of miscellaneous lines for disease index (DI) and % healthy roots in 1975. Means within columns followed by the same letter are not significantly different (P = .05).

Entry no.	Population	DI	% healthy
946	FC 701/5	1.9 a	68 a
992	f 106; Logan breeding line	5.7 b	3 b
985	(H65-02-69) CMS X Polish 203/71 (4n)	5.9 bc	1 b
973	Amer. #4 Hyb. A	6.3 bc	0 b
964	Polish Mono-I-HAR (4n); mm	6.4 bc	1 b
958	Amer. #2 Hyb. B	6.4 bc	4 b
957	HH-21	6.5 bc	0 b
955	Mono Hy A1	6.6 bc	0 b
986	Polish 203/71 (4n)	6.6 bc	0 b
956	Mono Hy D2	6.7 c	0 b
960	US H10B	6.7 c	0 b
959	US H20	6.7 c	0 b

Rhizoctonia Resistance of Susceptible X Resistant Hybrids.--R. J. Hecker and E. G. Ruppel.

In a continuing examination of dominance for resistance to rhizoctonia root rot, seven susceptible X resistant hybrids were tested in six replications in 1975. These hybrids and their parents are listed below in Table 1. The female parents were all CMS's supplied by BSDF member-company breeders. The females are all susceptible, but entry 977, supplied by American Crystal Sugar Company, is slightly less susceptible than the others, as indicated by its disease index of 5.7.

For disease index (the most precise measure of resistance), the hybrids showed partial dominance for resistance or no dominance. However, only hybrid entry 980 was significantly more resistant than its mid-parent value.

Partial dominance for resistance along with a dosage effect in triploid hybrids (using a tetraploid pollinator), which we reported in 1974, holds promise that resistance may be necessary in only one parent of commercial hybrids. However, when considering triploid hybrids it appears generally advantageous from a sugar production standpoint to use a tetraploid female. This complicates the breeding problems considerably. In order to produce a resistant tetraploid female for use in a commercial hybrid, one would need a CMS line, its maintainer line, and a type O line, all as resistant tetraploids. It would take a decade or more to develop these lines. Hence, for

the near future it is likely that hybrids with rhizoctonia resistance will have to result from crosses of susceptible diploid CMS's by resistant diploid or tetraploid pollinators.

Table 1. Comparison of hybrids among rhizoctonia susceptible and resistant parents. Means within columns followed by the same letter are not significantly different (P = .05). Mid-parent values are in parentheses.

Entry no.	Hybrid or parent	DI	% healthy
	Susceptible X Resistant Hybrids		
971	(562 CMS X 546) X FC 703	4.5 bc (5.1)	13 c (14)
975	(11866 X 12163) X FC 703	4.9 cd (5.3)	7 cd (13)
980	GW-918 MS X FC 703	3.9 ab (5.1)	25 b (14)
982	(H65-02-69) X FC 703	4.6 bc (5.1)	16 c (13)
987	7301 X FC 703	5.3 c (5.3)	5 cd (13)
976	63-(5HO X 6) X FC 701/4	4.4 bc (4.4)	15 bc (19)
978	9399-02 X FC 702/4	5.1 c (4.9)	5 cd (17)
	Resistant Parents		
961	FC 703	3.7 ab	27 ab
951	FC 701/4	3.1 a	38 a
952	FC 702/4	3.2 a	35 a
	Susceptible Parents (all CMS)		
972	562 CMS X 546, F_1	6.5 ef	2 d
974	11806 X 12163, F_1	6.8 f	0 d
977	63-(5HO X 6)	5.7 de	0 d
979	9399-02	6.6 ef	0 d
981	GW-918	6.5 ef	2 d
983	H65-02-69	6.4 ef	0 d
988	7301	6.9 f	0 d

Evaluation of Contributed Lines.--E. G. Ruppel and R. J. Hecker.

Separate randomized block designs with five replications were used to evaluate lines from American Crystal, Great Western, Holly, and Spreckels Sugar Companies. Lines from Amalgamated and Utah-Idaho Sugar Companies were combined in one experiment. A total of 81 contributed lines were tested. Resistant cultivar FC 703 was included twice in each test as a control. Results of each company's test were statistically analyzed and sent to company breeders,

thus, they will not be reproduced here. Generally, the resistant controls had significantly less rot than other entries, and hybrids with resistant parentage were more resistant than entries having no history of selection or breeding for rhizoctonia resistance. The disease index (D.I.) range on a scale of 0 to 7 for cultivar FC 703 was 1.4-4.6 ($\bar{x}$ = 2.9), whereas for the contributed lines the range was 2.0-7.0 ($\bar{x}$ = 6.0). Percentage healthy roots for FC 703 ranged from 8.0-83.3 ($\bar{x}$ = 42.2)%, whereas for the other entries the range was 0-61.6 ($\bar{x}$ = 4.4)%.

Rhizoctonia Resistant Breeding Lines Evaluated for Leaf Spot and Curly Top Resistance.--R. J. Hecker, G. A. Smith, and E. G. Ruppel.

In our rhizoctonia resistance breeding program, some effort has been devoted to developing lines which combine resistance to Rhizoctonia, cercospora leaf spot, and curly top. A group of these breeding lines were evaluated for leaf spot resistance in 1975. A few of the lines were also in Dr. Dave Mumford's curly top evaluation nursery in 1975, and in our rhizoctonia nursery. Table 1 below lists these lines and their disease evaluations.

This very limited test and earlier experience shows promise for the combination of rhizoctonia and leaf spot resistance. However, our experience up to now indicates that curly top resistance will be difficult to maintain even in lines backcrossed to LSR-CTR sources. Entries 1836, 1837, and 1840 in this test all represent relatively good levels of rhizoctonia and leaf spot resistance. However, the curly top resistance of 1837 is not promising.

A limited amount of effort will be continued in combining resistance to all three diseases in order to gain breeding and genetic information about their combination.

There are only a few production areas where this combination of resistance to the three diseases is needed, namely, Texas, Arkansas Valley, and limited areas in Arizona and California. It is likely that hybrid combinations can be put together even now, from parents individually resistant to these diseases, which would be as good as lines bred for combined resistance. This is particularly likely in the case of rhizoctonia resistance which has rather consistently shown some partial dominance for resistance.

The combination of high curly top and rhizoctonia resistance would be particularly useful in some areas such as the northwest. In these curly top prone areas, curly top resistance is needed in all parents of commercial hybrids. Hence, rhizoctonia resistance can only be injected into a hybrid if curly top resistance is not sacrificed.

Table 1. Disease ratings of breeding lines with potential for combining rhizoctonia, leaf spot, and curly top resistance. Leaf spot rated 0 to 10, rhizoctonia 0 to 7, and curly top 0 to 10, with 0 being resistant in each case. Means within columns followed by the same letter are not significantly different.

Entry no.	Breeding line	Disease ratings		
		Leaf spot	Rhizoc. DI	Curly top
1836	LSR-CTR, mm, TO X FC 701, $B_1P_1OP_2$	2.4 a	4.3 d	-
1843	(FC 504 CMS X FC 502/2) X SP 6322-0; LSR check	2.6 ab	-	-
1837	LSR-CTR, mm, TO X FC 701; 2 cy.Rh.sel.	2.7 abc	2.7 ab	6.5
1828	FC 702/5	2.9 bcd	2.4 a	-
1840	LSR-CTR, mm, TO X FC 701; 2 cy.Rh.sel.	3.0 bcde	2.7 ab	-
1826	FC 702/5 X FC 701/5, F_2	3.1 bcdef	-	-
1831	SP 5831-0; selected for Rh.res.	3.2 cdef	-	7.0
1835	Syn. of Rh.res. progeny lines	3.2 cdef	3.4 bc	-
1841	FC 703/1	3.2 cdef	2.2 a	6.5
1838	GW 674; source of FC 701 series	3.2 cdef	5.8 e	-
1827	FC 701/5	3.4 def	1.9 a	7.5
1833	LSR-CTR, mm, TO X FC 701, $B_1P_1OP_2$	3.5 efg	4.5 d	-
1829	FC 703	3.5 efg	3.7 cd	-
1834	FC 801	3.6 fg	3.6 bcd	6.0
1839	High yield syn; source of FC 702 series	3.6 fg	6.1 e	-
1832	LSR sel. X suc. sel; from B. vulgaris X B. maritima	4.0 g	-	4.0
1842	Syn. check; LSS check	7.0 h	-	-
	US 33; CT check	-	-	4.5

Effect of Nitrogen Fertility Level and Herbicide on Intensity of Rhizoctonia Root Rot.--R. J. Hecker and E. G. Ruppel.

It is generally agreed by experienced observers that rhizoctonia root rot is becoming an increasingly serious problem in many sugarbeet production areas. It is believed that this is primarily due to the increasing use of short rotations. However, it might also be affected by commercial cultural practices such as nitrogen fertility, herbicides, nematocides, etc.

An experiment to test some of these relationships was conducted in 1975. In a split-split-plot experiment, we tested the effect of Ro-Neet and different nitrogen fertility levels on the intensity of Rhizoctonia infection. Dates of planting, etc. are described in the introductory part of this report section. Our herbicide treatments were (1) no Ro-Neet, (2) 3 lbs Ro-Neet (AI/A spray broadcast and incorporated 4 days preplant). Our

three nitrogen treatments were (1) no applied N, (2) 80 lbs actual N per acre (5 days preplant as ammonium nitrate), and (3) 180 lbs of actual N per acre (80 lbs preplant and 100 lbs side-dressed after thinning). Results showed that there was about 105 lbs of residual nitrate nitrogen per acre in the top 18 inches of soil in experimental area. Hence, the three treatments could be considered nitrogen deficient, optimum, and excessive. Three populations were included in the experiment, namely, (1) FC 701/5, rhizoctonia resistant, (2) a polycross synthetic with intermediate rhizoctonia resistance, and (3) FC 901, rhizoctonia susceptible.

An analysis of variance of disease indices showed significant differences between populations but no significant differences due to herbicide treatment or nitrogen fertility level. The means for treatments and entries are shown in Table 1. Hence, Ro-Neet had no effect on the amount of rhizoctonia root rot which developed, nor was the amount of rot affected by the nitrogen fertility level.

The conditions of this experiment are not exactly comparable to normal commercial cultural conditions since the experiment was planted late and the inoculum was applied topically to the growing plants rather than being present saprophytically in the soil. However, under commercial conditions it appears likely that the intensity of rhizoctonia root rot would be unaffected by nitrogen fertility level and the herbicide Ro-Neet. Experiments simulating commercial conditions are planned for 1976 to determine if other herbicides, nematocides, and insecticides have an effect on the incidence of rhizoctonia root rot.

Table 1. Rhizoctonia disease index means for treatments, entries, and entries within treatments.

Herbicide treatment	Entry 1 (resistant)	Entry 2 (intermed.)	Entry 3 (suscept.)	Mean
no Ro-Neet	4.5	5.7	7.0	5.7
3 lbs Ro-Neet	4.7	5.6	7.0	5.8
Nitrogen treatment				
0 applied N	4.8	5.3	6.9	5.6
80 lbs applied N	4.4	5.8	7.0	5.7
180 lbs applied N	4.6	5.8	7.0	5.8
Mean	4.6	5.6	7.0	5.7

LSD (.05, for herb. trmt) = 0.15
LSD (.05, for N trmt) = 0.26
LSD (.05, for entries) = 0.25

Longevity of Rhizoctonia Inocula Grown for Different Durations before Preparation.--E. G. Ruppel.

Isolate R-9 was grown on moist barley grain for 2, 4, and 6 weeks in 1974 before the inoculum was dried and ground. In a 1974 field test, disease severity in sugarbeet was inversely proportional to length of growth duration, with disease indices (scale of 0 to 7) of 6.9, 5.5, and 2.5 for 2-, 4-, and 6-week inoculum, respectively. The inocula were stored in a refrigerator and the field test was repeated in 1975. Disease indices were almost identical to those obtained in 1974, with 6.9, 5.3, and 2.4 for 2-, 4-, and 6-week inoculum, respectively.

Anastomosis Grouping of Rhizoctonia solani Isolates from Sugarbeet.--E. G. Ruppel.

Four anastomosis groups (AG) are recognized among isolates of *R. solani*. The ability of any two isolates to anastomose in vitro is indicative of a genetic relationship; nonrelated isolates will not anastomose with isolates from a different AG. Previous tests showed that all sugarbeet root isolates were affiliated with AG-2, whereas damping-off or foliar-blight isolates were in AG-4. Isolates collected in the past 3 years were paired in culture with tester isolates representing the four AG's. Again, all root isolates fell into AG-2, and damping-off isolates aligned with AG-4. As before, AG-2 isolates were slower growing and more strongly pigmented than the lighter colored rapidly growing AG-4 isolates. Since the AG-4 isolates cause little, if any, rot of mature sugarbeet roots, care should be taken in selecting isolates for research on sugarbeet root rot.

CERCOSPORA INVESTIGATIONS, 1975

1975 Leaf Spot Evaluations of Sugarbeet Lines Submitted by BSDF Member-Companies.--G. A. Smith and E. G. Ruppel.

The 1975 induced leaf spot epidemic at Fort Collins was severe and provided a uniform intense infection. The leaf spot susceptible check ranged from 6.5 to 7.3 and averaged 6.7. The epidemic developed uniformly and slowly until about August 29, at which time it rapidly became severe. The cercospora nursery was planted April 23, 1975, as compared to May 15 in 1974, and was inoculated July 3, 1975, as compared to July 18 in 1974. The entire nursery was sprinkled for 2 days prior to inoculation and the post inoculation sprinkling was altered from previous years. In addition, the entire nursery was surrounded on three sides by a tall growing variety of corn to reduce the effects of wind currents across the nursery. Leaf spot readings were taken on August 29, September 2, and September 8. The epidemic reached a peak on or about September 7. This year we evaluated 168 lines which were submitted by five companies. As in the past, results of these tests were tabulated and sent to each respective BSDF member-company.

Curly Top Evaluation of LSR-CTR Lines Developed at Fort Collins.--G. A. Smith.

Table 1 presents the CTR evaluations of some lines developed in our LSR-CTR breeding program at Fort Collins. The curly top epidemic at Logan was not as severe as in past years but did provide good comparative data in our test. FC 605 was developed for resistance to leaf spot and for resistance to curly top. It has more resistance to leaf spot than to curly top. FC 506 CMS was developed to have resistance only to leaf spot. L-35 developed at Logan is highly resistant to curly top and highly susceptible to leaf spot. Both of these lines were used in crosses to leaf spot resistant or leaf spot and curly top resistant lines developed at Fort Collins. In addition, the lines were crossed to each other. As might be expected, when FC 605 was crossed to lines developed for resistance to both leaf spot and curly top (entries 2 and 4) a higher curly top resistance was seen than when FC 605 was crossed to lines developed only for leaf spot resistance (entry 3). The reaction of entries 2 and 4 is especially noteworthy because while both had relatively good curly top resistance, they both also give good resistance to leaf spot. The crosses involving L-35 all gave high curly top resistance ratings. However, these same crosses can be expected to have lower than acceptable leaf spot resistance.

Table 1. Curly top reaction of some more promising lines tested at Logan, Utah, 1975. Test conducted by G. A. Smith and D. L. Mumford.

Entry no.	Seed no.	Description	CTR[1/]
1	751022HO	FC 605, T.O., mm	4.0
2	751022HO2	FC 605, X (701212HO3 = 642027s1 CMS X 662119s1, T.O., high res. to CT infec., mm, vigorous)	3.0
3	751022HO4	FC 605 X FC 506 CMS = 731082HO1	4.0
4	751022HO5	FC 605 X 701212HO2 = (622016s1-CMS X 662119s1, T.O., LSR-CTR mm)	2.5
5	751030	731021HO = 662110s1 from 641157-(001), T.O., mm, res. to CT infection	3.5
6	751032HO2	L-35, T.O., mm X FC 605 CMS	2.0
7	751032HO3	L-35 X (701212HO3 = 642027s1 CMS X 662119s1, T.O., mm, high res. to CT infection)	2.0
8	751032HO4	L-35 X (701212HO2 = 652016s1-CMS X 662119s1, T.O., mm, high res. to CT infection)	1.5
9	751032HO5	L-35 X FC 506 CMS	3.5
10	741026H2	♀ progeny seed from roots sel. for high LSR and intercrossed to high sucrose selected roots from original McF 663 X F_3 from cross (SL 539 ♀ X *B. maritima* X US 22/4) X high suc. sel. of *B. maritima* X McF 413 and McF 663)	4.0
11	741031HO5	721028HO X (711154HO2 = 632028s1 X FC 601 X 662119s1)	3.5
12	701032HO	L-35, CTR, T.O., mm, check	1.0
13		US 41, check	4.5
14		US 33, check	6.5

[1/] Curly top ratings based on 0-10 scale (0 = no symptoms and 10 = death of plants). Tests conducted with two replications of single row plots.

Agronomic Test of Crosses with Varying Combinations of Leaf Spot, Curly Top, and Rhizoctonia Resistance.--G. A. Smith and R. J. Hecker.

Thirty-three experimental crosses developed at Fort Collins in the disease resistance breeding programs were evaluated under non-disease conditions at the Colorado State University Agronomy Research Center. Field conditions and plot establishment were good except for the unusually high

amount of residual nitrogen which was evidenced by the luxuriant foliar growth and by the low sucrose percentages of all tests in the field.

The highest gross sucrose crosses were in crosses using FC 701/2 as the pollen parent. The female sides of these crosses involved sublines of FC 601 and FC 603 and FC(504 X 502/2). FC 701/2 continues to show good combining ability for sucrose. The recently released FC 605 in crosses with an American Crystal high sucrose, multigerm, line resulted in high gross sucrose. Our combining ability information for FC 605 is still limited but we are beginning to see some good results for gross sucrose and LSR-CTR resistance when the pollinator line has good sucrose per se.

The Quantitative Effect of Cercospora Leaf Spot on Sugarbeet Yield and Yield Components.--G. A. Smith.

The foliar effects of cercospora leaf spot and the classification of damage by visual rating systems is well recognized and has been documented. On the other hand, the actual quantitative effect of Cercospora on yield and yield components according to degree of infection has not been well documented and has often been more speculation than fact. The major factor for this lack of quantitative data is the inability to grow infected and non-infected genotypes under identical environments (i.e. the same year at the same time in the same experiment). The success of any such experiment designed to test the effect of degree of infection rests in having genotypes in the same experiments each of which has a recognized infection level and each of which is disease free.

We have been able to design such an experiment and the following is a summary and discussion of the first of 2 years data from that experiment.

Eight genotypes with known degrees of leaf spot resistance (see Table 1) were field planted in two-row plots with 4 replications. Each two-row plot was bordered on each side by a red beet buffer row. Each genotype occurred twice in each replication so that the design was in essence a split block design. One of each of the two-row plots of each entry of each replication was sprayed with a water solution of benomyl at the rate of 3.2 grams per 2 gallons of water (8 ounces per acre). Plots were sprayed every 2 weeks beginning June 26 (before Cercospora inoculation), and continuing through September 3. The experiment was inoculated with Cercospora July 3, using our standard procedures.

Visual leaf spot ratings were taken on all plots twice and at the peak of the epidemic, September 8. Roots were harvested and weighed October 7, and then processed through the sucrose laboratory.

Results

Plots of each genotype which were sprayed with benomyl were nearly completely void of leaf spots. All benomyl treated plots rated 0 on our 0-10

leaf spot scale. Plots of genotypes which were not benomyl treated ranged from 1.0 to 7.0, with entries ranging from 2.0 to 6.4. Leaf spot ratings of untreated plots, root weight, sucrose %, purity %, and recoverable sugar for the genotypes, diseased and disease free, are presented in Table 2.

All genotypes except the most resistant entry 1817 showed a reduction in recoverable sugar and its components when infected with Cercospora. Average leaf spot ratings of 2.13 and 2.5 reduced recoverable sugar 6.2% and 7.3%, respectively. An average leaf spot rating of 3.25 reduced recoverable sugar 8.1% while an average rating of 4.63 reduced recoverable sugar 20.1%. Average leaf spot ratings of 6.13, 6.25, and 6.38 reduced recoverable sugar by 24.5%, 20.8%, and 38.1%, respectively. Of the components of recoverable sugar, root weight was reduced the most, followed by sucrose % and purity % (see Table 3). The split-block analysis of variance indicated a significant genotype X treatment interaction for recoverable sugar, sucrose %, and root weight. This result is understandable when one considers that not all genotypes with the same leaf spot rating reflect the same amounts of reduction in yield or yield components. This appears to be particularly true at the lower levels of leaf spot infection. Entry number 1817, which had an average leaf spot rating of 2, showed no reduction in yield or in the components of yield. The other two genotypes which had leaf spot ratings of 2.13 and 2.5 showed reductions in recoverable sugar and reductions in all of its components.

Correlation coefficients between degree of leaf spot, and the differences between infected and non-infected plots for sucrose %, recoverable sugar, root weight, and purity were $r = .73$, $r = .74$, $r = .66$, and $r = .46$, respectively. All of these values were significant and indicate the association of increasing leaf spot severity and reduction in sucrose yield. When differences between benomyl treated and non-treated plots (disease-free minus diseased) were regressed on degree of leaf spot, regression coefficients of $b = 1.37$ for sucrose %, $b = 1.28$ kg/plot for recoverable sugar, $b = .98$ for purity %, and $b = .66$ kg/plot for root weight were obtained. Ideally these values could be used to indicate the number of units change that would be expected for each unit change in degree of leaf spot. However, care must be taken in their direct use because standard errors were relatively high and because not all genotypes with the same degree of leaf spot infection reflect the same amount of reduction in yield or in the components of yield. However, judicious use of these values and the % reduction figures as presented in Table 3, do give us good estimates of quantitative reductions in recoverable sugar and its component factors for various levels of leaf spot infection.

Table 1. Varieties used to detect quantitative effects of cercospora leaf spot infection.[1/]

Entry	Seed no.	Variety description
1817	671201H08	FC(504 X 502/2) X SP 6322-0, LSR, mm
1818	A74-53	SP 7322-0, LSR
1819	731083	Synthetic check, LSS
1820	661027-0	Variety A, LSS
1821	Acc. 2168	Variety B, GW 674-56C, Inter. LSR
1822	A75-1	Holly HH-21, Inter. LSR
1823	A75-2	GW Mono Hy D2, Inter. LSR
1824	A73-13	Am. #2 Hyb. C (FC 506 X FC 902) LSR

[1/] All genotypes occurred twice in each of four replications. Plots were 20 foot long, 2 rows and bordered on each side by red beet buffer to protect against drift from plots sprayed with benomyl.

Table 2. Summary of the quantitive effect of cercospora leaf spot on sugarbeet.

Geno-type	L.S.[1/] reading	$\bar{x}$ Root weight[2/]		$\bar{x}$ Sucrose %		$\bar{x}$ Purity %		$\bar{x}$ Recov. sugar[2/]	
		Disease free	Diseased	Disease free	Diseased	Disease free	Diseased	Disease free	Diseased
1817	2.00	39.3	39.4	19.19	19.60	95.34	95.44	6.83	6.99
1824	2.13	42.6	39.3	19.11	19.53	95.57	95.40	7.41	6.95
1818	2.50	36.4	35.2	18.72	18.12	95.21	94.69	6.15	5.70
1821	3.25	38.5	36.7	19.30	18.89	95.15	94.50	6.71	6.16
1823	4.63	48.4	40.1	19.73	19.28	95.39	94.70	8.65	6.91
1822	6.13	44.7	36.5	19.24	18.10	94.79	94.05	7.70	5.81
1820	6.25	33.1	29.2	19.63	17.94	94.81	93.70	5.81	4.60
1819	6.38	42.6	30.6	19.74	17.59	94.47	92.97	7.48	4.63
Avg	4.15	40.7	35.8	19.33	18.63	95.09	94.43	7.09	5.97

[1/] The average leaf spot rating of 4 replications (2 row plots) taken 9-8-75 on non-benomyl sprayed plots. All benomyl treated plots average 0 leaf spot.

[2/] Root weights and recoverable sugar are in kilograms per plot.

Table 3. % reduction of Cercospora-infected versus non-infected for eight genotypes.[1/]

Genotype	L.S. rating	Root weight (kg)	Sucrose %	Purity %	Recov. sugar (kg)
1817	2.00	+ .2%	+ 2.1	+0.1%	+ 2.4%
1824	2.13	- 7.7	- 2.1	-0.1	- 6.2
1818	2.50	- 3.3	- 3.2	-0.5%	- 7.3
1821	3.25	- 4.6	- 2.1	-0.7%	- 8.1
1823	4.63	-17.1	- 2.3	-0.7%	-20.1
1822	6.13	-18.3	- 5.9	-0.8%	-24.5
1820	6.25	-11.8	- 8.6	-1.2%	-20.8
1819	6.38	-28.1	-10.9	-1.6%	-38.1

[1/] % reduction means the average % difference between plots sprayed with benomyl (disease free) and those plots not sprayed and infected to the degree indicated in column two.

The Occurrence of Root Sprangling following Treatment with Benomyl.--G. A. Smith.

In a field experiment originally designed to detect quantitative differences among degrees of leaf spot infection, a noticeable difference was seen in the amount of root sprangling between benomyl sprayed and non-sprayed plots of the same genotype.

In the experiment, eight genotypes ranging from susceptible to resistant were field grown in 20 foot, two-row plots. Each genotype occurred twice in each replication. One of each of these two plots of each genotype was sprayed with a water solution of benomyl at the rate of 3.2 grams per 2 gallons of water (8 ounces per acre). Plots were sprayed June 26, prior to inoculations with *Cercospora* and at two week intervals thereafter through September 3. Red beet buffer rows bordered each plot to prevent any over spray between treated and untreated plots. Plots which had been treated with benomyl showed no infection symptoms during the growing season or at harvest.

Plots were harvested October 7 and roots of all plots (benomyl treated and non-treated) were classified as sprangled or unsprangled. Roots classed as sprangled were those which had a significant branch two inches or more above the root tip.

The analysis of variance indicated a significant difference in sprangling among genotypes and a significant difference between benomyl-treated and untreated plots. Two of the eight genotypes showed variation among replications which caused mean values to reflect little or no effect of the benomyl treatment. Thirty percent of all roots (across genotypes) which were in sprayed plots were sprangled compared to 24% for non-sprayed plots.

Root classification data were arranged in a 2 X 2 contingency table and the null hypothesis of "no difference in number of sprangles between benomyl-sprayed or non-sprayed" was tested. A X^2 value of 13.7 with $P < .005$ was obtained. Consequently, the null hypothesis was rejected and it was concluded that a significant increase in sprangling occurred as a result of the benomyl spray treatment. Other potential causes of sprangling such as soil compaction or nematodes were eliminated as explanations for the sprangling. Further investigation is planned to confirm these data.

Benomyl-Tolerant Strains of Cercospora beticola from Arizona.--E. G. Ruppel (in cooperation with L. M. Burtch and A. D. Jenkins, Spreckels Sugar Division, Amstar Corporation).

Observations in the Willcox area of Arizona in 1974 and 1975 indicated diminished effectiveness of benomyl for the control of cercospora leaf spot. Ninety monospore isolates of *C. beticola* from leaf spot-infected sugarbeets grown near Willcox in 1975 proved to be highly tolerant of benomyl in vitro.

To determine the degree of benomyl tolerance, 20 randomly selected isolates and a benomyl-sensitive isolate (C-1) were plated on potato-dextrose agar containing 0, 1, 10, 100, and 1000 ppm a.i. benomyl/ml. Measurements of linear growth after 7 days revealed that the Arizona isolates had varied degrees of benomyl tolerance similar to those isolates previously reported from Texas. The ED_{50} (concentration causing 50% growth inhibition) of nine isolates was between 100 and 1,000 ppm, whereas four isolates had an ED_{50} of 100 ppm. Six isolates had an ED_{50} between 10 and 100, and only one isoalte had an ED_{50} of 10 ppm. Isolate C-1 only grew on the benomyl-free medium. No isolate was as tolerant as H1-12 (ED_{50} = between 1,000 and 5,000 ppm) from Texas.

Alternating benzimidazole and protectant-type fungicides has not adequately controlled sugarbeet leaf spot in Texas. Continued use of benzimidazoles for control in Arizona and Texas cannot be recommended, and exclusive use of these selective chemicals in other areas should be discouraged.

Effect of Benomyl on In Vitro Biology of Benomyl-Tolerant Strains of Cercospora beticola.--E. G. Ruppel.

Previous studies showed that benomyl-tolerant strains as a group were no different from sensitive strains in growth and sporulation in vitro, or in virulence and sporulation in vivo in the absence of benomyl. The present research was conducted to study the biology of tolerant strains in vitro in the presence of benomyl.

Sugarbeet leaf extract agar (SBLEA) containing 0, 1, and 10 ppm a.i. benomyl/ml was used for the growth and sporulation studies of benomyl-tolerant strains HB-6 and H1-12 from Texas. A benomyl-sensitive strain (HC-10) from Texas was included as a control. Sporulation of the isolates was induced after 10 days of growth on SBLEA by placing the cultures under continuous light at 15 C for 5 days. Comparative criteria included linear growth, conidial production, conidial germination, and conidial morphology (L/W ratios).

Results (Table 1) showed that linear growth tended to decrease with increased benomyl concentration, with the inhibitory effect being more pronounced on strain HB-6 than on H1-12. No significant differences in conidial production were found between the tolerant strains on varied benomyl concentrations; however, viability of conidia tended to decrease with increasing benomyl concentrations. The L/W ratios of conidia produced on benomyl-amended medium were somewhat variable, but there was a trend toward smaller ratios in both tolerant strains at the highest concentration of benomyl.

Table 1. Linear growth, conidial production, and viability and L/W ratios of conidia of benomyl-tolerant strains of *Cercospora beticola* grown on benomyl-amended sugarbeet leaf extract agar (SBLEA).

		Response of strains of *Cercospora* to benomyl[2/]			
			Conidia		
Fungus strain[1/]	Benomyl (ppm)	Colony diam[3/] (mm)	Conidia/ml[4/] ($X10^4$)	Germination (%)	L/W ratio
H1-12	0	35 a	1.9 b	90 a	38 ab
	1	35 a	1.9 b	91 a	42 a
	10	33 a	2.3 ab	84 a	34 bc
HB-6	0	23 b	2.7 ab	72 b	35 bc
	1	20 c	2.7 ab	59 c	29 c
	10	14 d	2.5 ab	55 c	21 d
HC-10	0	35 a	3.5 a	89 a	40 ab

1/ H1-12 and HB-6 = benomyl-tolerant strains; HC-10 = benomyl-sensitive strain (HC-10 did not grow on benomyl-amended SBLEA).

2/ Means of four replications; means followed by the same letter within columns did not differ significantly by Duncan's multiple range test at P = 0.05.

3/ Measured after 10-days growth at 26 C.

4/ Sporulation induced after 10 days of growth on SBLEA at 26 C by placing the cultures under continuous fluorescent light at 15 C for 5 days.

Tolerance to benomyl obviously is not an all-or-nothing phenomenon, and tolerant strains can be affected adversely by increases in fungicide concentrations. But it would be erroneous to conclude that increasing field

rates would eliminate tolerant strains. Such an approach would only increase the selection pressure for tolerance, and may result in an irreversible shift to complete dominance of highly tolerant strains.

Effect of Benomyl on Virulence of Benomyl-Tolerant Strains of Cercospora beticola In Vivo.--E. G. Ruppel.

Two-month-old plants of sugarbeet cultivar R & G Pioneer were irrigated with 300 ml (per 15-cm diameter pot) of aqueous benomyl solutions at concentrations of 0, 100, and 1,000 ppm 72 hours before inoculation. The same solution used as a soil drench also was atomized on the foliage until leaves were thoroughly wetted. Plants were inoculated with aqueous spore suspensions (25,000 spores/ml) of strains HB-6, H1-12 (both benomyl tolerant) and HC-10 (benomyl sensitive) and held in a humidity chamber for 96 hours at 100% relative humidity and 27 C. Disease severity was recorded 21 days after inoculation on a disease index (D.I.) scale of 0 to 5 (0 = no leaf spot, and 5 = complete defoliation). Four replications were used in a randomized complete block design in each of two tests. Decreases in disease severity caused by both benomyl-tolerant strains in sugarbeet occurred with each increase in benomyl concentration as shown in the following table:

Fungus strain	Benomyl (ppm)	Mean D.I. Test 1	Mean D.I. Test 2
H1-12	0	3.4 a	3.1 a
	100	2.4 b	2.9 a
	1,000	1.5 cd	2.5 b
HB-6	0	3.3 a	1.8 c
	100	2.1 bc	1.6 c
	1,000	1.3 d	0.9 d
HC-10	0	1.5 cd	2.5 b
	100	0	0
	1,000	0	0

Cercosporin Production by Cercospora beticola Grown on Several Agar Media.--E. G. Ruppel and S. S. Martin.

Cercosporin, a phytotoxin produced by several *Cercospora* species, is produced in vitro and in vivo. To determine the optimum medium for maximum cercosporin production in vitro, *C. beticola* isolate C-2 was grown for 7 days at 26 C under continuous fluorescent light (ca. 775 lx) on corn meal (CMA), Czapek's solution (CSA), potato-dextrose (PDA), prune (PA), and sugarbeet leaf extract (SBLEA) agars in 9-cm diameter petri dishes. Cultures were

initiated with aliquots of an aqueous spore suspension. The contents of each petri dish were sonicated in ethyl acetate. After filtering and concentrating by flash evaporation, the residues were resuspended in 3 ml chloroform, purified by column chromatography, and cercosporin concentration determined spectrophotometrically. The following amounts of cercosporin in µg/culture were obtained (means of four replications): PDA, 360; PA, 41; CMA, 36; CSA, 17; SBLEA, 9. PDA was significantly better than the other media for cercosporin production.

Comparison of Potato-Dextrose Agar (PDA) and Broth (PDB) for Cercosporin Production by Cercospora beticola.--E. G. Ruppel and S. S. Martin.

Five mycelium-agar disks from 7-day-old cultures of *C. beticola* isolate C-2 were used to inoculate flasks of PDB and petri dishes of PDA. The cultures were incubated under continuous light (387 lx) for 10 days when ethyl acetate extractions were made from entire PDA cultures and from broth and mycelia of PDB cultures. Cercosporin was concentrated, purified, and analyzed as described elsewhere in these reports. Amounts of cercosporin obtained in µg/culture were (means of four replications): PDA + mycelium = 289; PDB alone = trace; mycelium from PDB cultures = 10. PDA, obviously, was superior to PDB for in vitro cercosporin production.

Decomposition of Cercosporin in Potato Dextrose Broth Cultures of Cercospora beticola.--S. S. Martin and E. G. Ruppel.

In the experiment described above, only small amounts of cercosporin were found in potato dextrose broth cultures of *Cercospora*, whereas the same isolates produced abundant cercosporin in agar cultures. We noted that early in the experiment, after a few days of growth, the broth cultures became orange, which suggested the presence of cercosporin in the medium. However, when the cultures were sampled after 10 days growth, the medium had become dark brown and only traces of cercosporin were detected. To examine the possible photo-destruction of cercosporin in broth cultures, a simple experiment was conducted. Potato dextrose broth cultures of *Cercospora* isolate C-2 were initiated as above. At 4 days after start of the experiment, two flasks were visually paired for orange color evident in the medium. One of the pair was analyzed at that time for cercosporin, yielding 108 µg total from broth and mycelial extract. The second member of the pair was covered with aluminum foil, then with heavy kraft paper; after 6 days covered (10 days from start) this flask yielded 13.8 µg cercosporin total. Control flasks, one similarly covered and one uncovered throughout the 10-day growth period, yielded 38.4 and 14.3 µg cercosporin, respectively. These data suggest that cercosporin is produced in PDB cultures of *C. beticola*, and that its destruction with time is not a result of photodecomposition alone.

In Vitro Cercosporin Production by Several Isolates of Cercospora.--E. G. Ruppel and S. S. Martin.

Cercosporin production of *C. beticola* isolates C-1, C-2, and C-15 grown for 10 days on PDA was 50, 130, and 100 µg/culture, respectively. In another test, isolate C-2 yielded 368, *C. apii* (isolate CA-2) 11, and isolate DH-2 (*C. beticola* from California) 5 µg/culture. Tests are underway to determine if quantity of cercosporin production in vitro is related to aggressiveness and virulence of the isolates in vivo.

Isolation of the Toxin Cercosporin from Cercospora beticola-infected Sugarbeet.--S. S. Martin.

Before a chemical compound produced in culture by a pathogen can be implicated as potentially involved in a disease, the toxic substance must be demonstrated to be produced by the pathogen in the living host. The phytotoxic pigment cercosporin had been isolated from peanut (*Arachis hypogaea* L.) infected by *Cercospora personata* (Venkataramani, K. 1967. Phytopath. Z. 58: 379.) and from the seed of soybean [*Glycine max* (L.) Merr.] infected by *Cercospora kikuchii* (Kuyama, S. and T. Tamura. 1957. J. Chem. Soc. 79: 5725.), but it had not been reported from sugarbeet infected by *Cercospora beticola*. A paper detailing the successful isolation of cercosporin from *Cercospora*-infected sugarbeet (cv. R & G Pioneer) has been approved for publication (see abstract this report).

Relationship of Lesion Size and Varietal Resistance to Cercospora beticola.--E. G. Ruppel.

Sugarbeet cultivars FC(504 X 502/2) X SP 6322-0 (highly leaf spot resistant), SP 6322-0 (moderately resistant), and R & G Pioneer (highly susceptible) were inoculated with aqueous spore suspensions of *C. beticola* isolates C-1 (Colorado) and DH-2 (California). Disease severity was evaluated 21 days after inoculation, and 100 random lesions on each plant were measured. Four replications were used in a randomized complete block design.

Mean disease severity on a scale of 0 to 5 (0 = no leaf spot) regardless of cultivar was 2.0 for isolate C-2, and 1.9 for DH-2. Leaf spot was significantly more severe in Pioneer ($\bar{x}$ = 3.0) than in the other cultivars ($\bar{x}$ of each = 1.4) regardless of isolate. Mean lesion diameter was dependent on isolate and cultivar. Lesions induced by isolate C-2 ($\bar{x}$ = 1.8 mm) were significantly larger than those induced by DH-2 ($\bar{x}$ = 0.9 mm). Lesions on Pioneer averaged 1.9 mm in diameter, whereas those on the highly and moderately resistant cultivars were 1.0 to 1.1 mm in diameter. There was no significant isolate X cultivar interaction for disease severity or lesion size.

Content of Two Possible Phytoalexins in Whole Sugarbeet Leaves Infected by Cercospora beticola.--S. S. Martin.

Two phenolic compounds had been isolated from leaf spot diseased sugarbeet leaves and the compounds suggested to be phytoalexins involved in resistance to the disease [Geigert, J., F. R. Stermitz, G. Johnson, D. D. Maag and D. K. Johnson, Tetrahedron 29: 2703 (1973)]. The two compounds are 2',5-dimethoxy-6,7-methylenedioxyflavanone and 2'-hydroxy-5-methoxy-6,7-methylenedioxyisoflavone; they were given the common names betagarin and betavulgarin, respectively (G. Johnson, pers. comm.). An experiment was conducted to determine the relationship of these compounds and disease resistance under field conditions.

Artificially inoculated diseased plants and controls were sampled at three times: (1) immediately before inoculation; (2) 25 days after inoculation, when mild disease symptoms were evident; and (3) 60 days after inoculation, when the epiphytotic was fully developed. Visual disease ratings were made at each harvest. Whole leaves were composited by replication, dried and finely ground, acetone extracted, and the extract partially purified by column chromatography on Sephadex LH-20. Final separation of betagarin and betavulgarin was by TLC and quantitation was by UV spectrophotometry.

Only traces of either compound were detected in leaves of control plants at any sampling date, or in diseased plants at the first two sampling periods. Contents of both compounds and disease ratings for diseased plants at the third sampling date are given in the following table.

Disease ratings and content of betagarin and betavulgarin in *C. beticola*-infected sugarbeet leaves 60 days after inoculation. Disease ratings on scale of 0 = no symptoms to 10 = complete defoliation. Data are means and std deviations of 4 replications.

Cultivar	Disease Rating		µg/g leaf dry wt			
			Betagarin		Betavulgarin	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
FC(504 X 502/2)-CMS X SP 6322-0	2.0	0.4	13	11	28	18
US 201	2.4	0.5	242	88	55	19
FC 506 X FC 701/2	2.1	0.6	104	54	54	20
652016s1-CMS X 661161H	3.0	0.7	99	28	29	12
SP 5822-0	3.1	1.6	55	30	35	22
US H9B	4.8	1.1	259	70	70	16
52-305 CMS X 52-334, F	5.4	1.8	306	137	66	14
R & G Pioneer	5.2	2.0	401	211	98	45
51-319 X 52-334, F	6.8	1.2	14	14	66	60

Differences among cultivars were highly significant in disease rating ($F = 7.76^{**}$) and betagarin content ($F = 8.53^{**}$), and approached significance in betavulgarin content ($F = 2.27$; $F_{0.05} = 2.31$). However, the correlation coefficient between mean betagarin content and mean disease rating was nonsignificant ($r = 0.39$), whereas the correlation between betavulgarin and disease rating was significant ($r = 0.66$). Bioassay of each compound against linear mycelial growth of *C. beticola* has shown betavulgarin to have significant antifungal activity, whereas betagarin had only slight activity (G. Johnson, pers. comm.; E. G. Ruppel and S. S. Martin, unpublished data). The bioassays and these data correlating disease ratings with compound content in whole leaves suggest that only betavulgarin may be acting as a phytoalexin. One might expect a negative correlation between betavulgarin content and disease rating rather than the positive correlation found. However, plants of susceptible cultivars had many more lesions than resistant ones, and it is possible that the quantity of compound per lesion would be negatively correlated with disease severity. Limited data, consisting of one sample from each of six sugarbeet cultivars, did appear to show a negative correlation between betavulgarin content of lesions (as µg compound per g dry wt of lesions) and known susceptibility to leaf spot disease (G. Johnson, pers. comm.). We are conducting further experiments on betagarin and betavulgarin content per lesion in cultivars of varying leaf spot susceptibility.

Betagarin and Betavulgarin Localization in Cercospora beticola-induced Leaf Spots.--S. S. Martin.

The possible phytoalexins betagarin and betavulgarin had been isolated by others and by us from *C. beticola*-infected whole sugarbeet leaves and from necrotic lesions. It was assumed but not experimentally demonstrated that the compounds were localized in lesions.

Leaf disc samples of four types were examined for betagarin and betavulgarin contents:

(1) necrotic lesions from living leaves;
(2) discs from non-lesioned areas of lesion-bearing leaves; each disc was at least 10 mm from any visible lesion;
(3) necrotic lesions from withered, dead leaves;
(4) discs from uninoculated controls.

Each sample consisted of 50 3-mm diameter discs cut out with a revolving hand punch. Betagarin and betavulgarin were extracted with diethyl ether, separated by TLC, and quantitated by UV spectrophotometry.

From 2 replicates each of 4 cultivars, betagarin contents from traces to 13 µg/50 lesions and betavulgarin contents from 5 to 28 µg/50 lesions were found. Neither compound was detected in visually normal areas of lesion-bearing leaves, in healthy controls, nor in withered, dead leaves. The stage or rate at which the compounds were lost between their presence in lesions on living leaves and their absence in lesions on dead leaves was not established.

Electron Microscopy of Cercospora beticola-infected Sugarbeet.--S. S. Martin, M. P. Steinkamp, and E. G. Ruppel.

Spores of the fungus *Cercospora beticola* germinate on sugarbeet leaf surfaces, and hyphae grow through stomatal pores into leaf intercellular spaces. Ultimately, following successful colonization of the leaf mesophyll, a necrotic lesion is formed. We used the electron microscope to follow degenerative changes in the mesophyll associated with lesion formation.

Initial changes were in the ground cytoplasm, with the endoplasmic reticulum altered in structure. The next degenerative changes appeared to occur without a definite sequence. Mitochondrial cristae were swollen, the nucleus showed increasing disorganization, and chloroplasts increased in starch and plastoglobuli and soon lost their bounding membranes. Effects on the tonoplast were variable, sometimes preceding these organelle effects, sometimes delayed. Ultimately the integrity of the tonoplast was lost, and organelles or their remnants were distributed throughout the cell interior. The plasmalemma degenerated, often leaving a row of lipoidal droplets at its former position. At this stage of the disease, cells were beginning to collapse; at the culmination of the process, in the necrotic stage of lesions development, cells were collapsed, filled with amorphous cytoplasm, and frequently contained apparently crystalline areas, presumably dissolved in specimen preparation.

Throughout the entire degenerative sequence, fungal hyphae were present in the intercellular space, often closely appressed and seemingly attached to the host cell wall. Wall appositions or depositions of material on the interior of the host cell wall were frequent, especially at points of fungal contact. Also present in intercellular spaces was a finely-granular, medium electron-dense substance, particularly abundant in the zone bounding the mature or fully enlarged necrotic lesion.

Because the fungal hyphae were found to remain completely intercellular, often contacting sugarbeet cell walls but not penetrating them, it seems probable that toxic substances produced by the fungus may be involved in the degenerative process. Initial ultrastructural examination of lesions produced in sugarbeet by application of the purified fungal toxin cercosporin showed a degenerative sequence partially resembling that of the pathogen-induced lesion.

POWDERY MILDEW INVESTIGATIONS, 1975

Sugarbeet Powdery Mildew in 1974-75. E. G. Ruppel.

Powdery mildew occurred in all sugarbeet growing areas in 1974-75, including new reports from Minnesota, Michigan, and Ohio. The disease appeared about 6 months earlier this year in Arizona and 3 months earlier in the Imperial Valley of California. In other areas, the disease appeared at the same time, or 1 to 2 months earlier.

Generally, reports indicate that powdery mildew was less severe and occurred more sporadically this year as compared to last season. Decreased severity and incidence could be due to increased control measures and, possibly, less favorable environmental conditions for the disease. Because of the late occurrence of powdery mildew in the north central States, very little loss in yield, if any, was expected.

Most growers used a Federally-registered wettable sulfur, or State-registered flowable and dusting sulfurs for control. Observations in Colorado and Texas indicated that at least 7 to 10 gallons of water were needed with flowables for adequate coverage and good disease control.

Efficacy of Several Fungicides for Control of Powdery Mildew in Sugarbeet.--E. G. Ruppel and G. A. Smith.

Powdery mildew first appeared in sugarbeets set aside for the fungicide test during the second week of September. Fungicides were applied but the disease did not progress even in the nontreated control plots. Thus, the experiment had to be abandoned.

Host Range Test of the Sugarbeet Powdery Mildew Fungus.--E. G. Ruppel.

Positive infections were obtained in *Beta atriplicifolia*, *B. lomatagona*, *B. macrocarpa*, *B. macrorhiza*, *B. maritima*, *B. patula*, *B. trigyna*, and *B. vulgaris* (red beet, sugarbeet, Swiss chard). No mildew developed on *Amaranthus retroflexus*, alfalfa, bean, three *Chenopodium* species, cockscomb, cucumber, globe amaranth, mustard, New Zealand spinach, pea, red clover, shepherd's purse, *Solanum dulcamara*, *S. sarachoides*, and spinach.

One of five *Chenopodium capitatum*, two of six *Beta patellaris*, and two of 12 *Rumex crispus* plants developed small mildew infections on one or two older leaves. The mildew did not spread or become severe on these plants and, in most cases, disappeared. These species are thought to be highly resistant.

Powdery mildew spores (*Erysiphe* spp.) from naturally infected field plants of *R. crispus* and *S. sarachoides* failed to infect sugarbeet in the greenhouse, whereas spores from sugarbeet growing in the same fields were highly infectious on sugarbeet.

Longevity of Powdery Mildew on Sugarbeet Leaves.--E. G. Ruppel.

Heavily infected leaves were collected from the field in October 1974 and dried 48 hours at room temperature. Samples were stored at room temperature, in a protected area outdoors, and buried 15-cm deep in soil outdoors. Each month, portions of stored samples were used to inoculate 2-month-old sugarbeets. Inoculum from leaves buried for 60 days was infectious. All other inocula, including subsequent monthly samples of buried inoculum, were noninfectious.

Longevity of Powdery Mildew Fungus on Sugarbeet Seed.--E. C. Ruppel.

Seed from heavily infected sugarbeets grown in Arizona in 1974 were planted monthly each year from November through April, and seedlings were observed for 30 days. In addition, samples of seed were ground with a mortar and pestle and dusted on 2-month-old sugarbeets. No seedlings developed mildew and no mildew occurred on inoculated plants.

BREEDING AND QUALITY RESEARCH

Research on Development of a Model to Explain Thin Juice Purity.--G. A. Smith, S. S. Martin, and K. A. Ash.

It is well known that impurity components or soluble nonsucrose constituents in sugarbeets impede crystallization and, consequently, lower extraction of sucrose. Potassium, sodium, amino nitrogen, and betaine are four such melassigenic components which have been reported to account for 80 to 90% of the refractometric nonsucrose constituents in second carbonation juice and are considered the most important nonsugar impurities with which the processor must deal. It is known that these four components are not the only components affecting purity %, but it is not known how these and other components affect purity under differing environmental conditions.

The objective of this research was to develop a model that would better explain purity. The first requirement in developing the model was to identify which components were the most important, and then to see if they maintained the same relative importance as environmental conditions changed. The most obvious controllable environmental factor known to affect sugarbeet quality is soil nitrogen fertility level. Another factor which is easily controlled but for which little is known of its effect on purity is plant population density. Therefore, our study was designed to study the effects of nitrogen fertility level and plant population density on purity % and the components that directly and indirectly affect purity. Data were collected in 1974 and 1975 from a split block field design with one nitrogen level of about 60 lbs/A of actual N applied preplant and high nitrogen fertility of an additional 100 lbs/A of actual N post plant side dressed. Plant population densities of 7,927, 11,890, 23,780, and 47,561 plants per acre were established. The three genotypes utilized in the study were GW Mono Hy D2, Holly HH-21, and FC 702/4. Purity % was determined using limed pressed juice, and nonsucrose purity components were determined on raw juice.

Path coefficient analysis was used to develop over 300 models representing various combinations of characters and their effect on purity. It is not the purpose of this report to describe the use of path coefficient analysis, but briefly stated, the method partitions the correlation coefficients between a dependent variable (in our study, purity %) and independent variables into direct and indirect effects. One of the chief attributes of

path analysis is that direct effects are expressed in standard deviation units and, hence, it is possible to compare the relative importance of a set of independent variables (in our study, the components affecting purity), each of which may have been measured in different units. The worth of any model developed by path analysis is immediately determined by calculation of its R^2 value. R^2 values range from 0-100% and indicate the percentage of variation in the dependent variable (in our study, purity) accounted for by the independent variables used in the path model.

Results

Table 1 shows the components that were included in the "full" or base model. From this full set of components other models were developed by subtracting various components and then testing the adequacy of each model by its R^2 value. Also included in Table 1 are the R^2 values representing the full model at high and low N and between years. Of particular note is the fact that R^2 values were very similar between years and nitrogen fertility levels even though the relative order of importance of the components within the models was somewhat different.

Average R^2 values and their ranges for the "full model" and three other models with removal of 2, 3, and 4 components, respectively, are presented in Table 2. Although dozens of component combinations were tested in the models studied, deletion of ash and total nitrogen from the model as in Table 2 was a logical step because ash and total nitrogen are conglomerate factors consisting chiefly of individual components still remaining in the model. Root weight and chloride were deleted from models because they were found to have little effect on thin juice purity. This fact became apparent when R^2 values were affected very little by their removal. The R^2 values presented in Table 2 are averaged over nitrogen fertility level, genotypes, and plant population densities because no clear cut trend for these factors was found in the over 300 models studied.

Because no universal model was found that consistently explained variation in purity under varying plant densities, genotype, or nitrogen level, a search was made for the components that occurred most frequently in the better models. Table 3 presents the top 3 components, those having the largest effect on purity, in each of the top 12 models. From this table the frequency of occurrence and a relative importance value for each component in the best models can be determined. These frequency of occurrence and importance results, shown in Table 4, indicate which components would most often be involved in an explanation of variation in purity %. From the results of this two year study, we have concluded that any model developed to explain variation in purity probably should include potassium, sodium, and betaine, and possibly also nitrate N, amino N, and sucrose. In general, the soluble nonsucrose constituents increased in quantity from high plant population density to low density (see p. C21, 1974 "Sugarbeet Research" report), but this linear change did not produce a significant effect on models constructed to account for thin juice purity either at high or low nitrogen fertility.

In previous studies, we determined that these same constituents are under genetic control and that all had a significant proportion of their total genetic variance accounted for by additive variance. In addition, potassium, betaine, and amino N displayed significant nonadditive genetic variance at low soil nitrogen, and nitrate N, amino N, and sodium also displayed significant nonadditive genetic variance at high nitrogen fertility. Because of the narrow range in purity generally observed and because of an apparent lack of additive genetic variance at low to medium nitrogen fertility levels, progress in improving purity by breeding for purity *per se* is likely to be very slow. However, modification of the components that directly and indirectly affect purity should be possible and if done properly should result in improved purity.

Table 1. The components affecting purity included in the "full model" and the average R^2 values for high and low N across plant population densities for 1974 and 1975.

Component	Average R^2 values
Ash Total N Amino N Nitrate N Betaine Sodium Potassium Sucrose Root weight	1974 Regular N, R^2 = 77.2% 1974 High N, R^2 = 75.1% 1975 Regular N, R^2 = 82.7% 1975 High N, R^2 = 72.2%

Table 2. Average R^2 values (%) and ranges for "full model"[1/] and for 3 models with 2 to 4 component deletions.

Model and deletions	R^2 1974	R^2 1975	1974 R^2 range	1975 R^2 range
Full model	76.2	77.4	45.1-94.7	46.6-93.0
-Ash,-total N	64.1	68.8	21.4-91.6	44.6-89.6
-Ash,-total N,-root wt	61.5	62.3	19.1-89.0	31.8-86.8
-Ash,-total N,-root wt, -chlorides	55.6	59.1	18.2-87.9	27.0-86.8

[1/] "full model" includes ash, chloride, total N, amino N, nitrate N, betaine, sodium, potassium, sucrose, root weight.

Table 3. The 3 most important purity component variables for the 12 best path coefficient models developed to explain thin juice purity.

R^2 of model	Top 3 constituents
94.7	sodium, potassium, betaine
93.0	ash, potassium, nitrate nitrogen
92.5	ash, potassium, nitrate nitrogen
91.8	sodium, amino N, nitrate nitrogen
91.6	potassium, sodium, betaine
91.3	potassium, betaine, chloride
91.2	betaine, sodium, total nitrogen
90.7	sucrose, nitrate nitrogen, betaine
90.2	ash, potassium, betaine
89.6	betaine, potassium, amino N
89.5	sodium, root weight, amino N
89.4	sucrose, sodium, betaine

Table 4. The frequency of occurrence and weighted importance of the top 3 variables for the 12 best path coefficient models developed to explain thin juice purity.

Variable	Frequency of occurrence 1/	Weighted importance value 2/
Betaine	8	13
Potassium	7	16
Sodium	6	15
Nitrate nitrogen	4	5
Amino nitrogen	3	4
Sucrose	2	6

1/ If variable had occurred 1st, 2nd, or 3rd in each of the 12 models, the frequency of occurrence would have been 12.

2/ Determined from the 12 best models by assigning a value of 3 for being the most important component in the model, 2 for the next most important, and 1 for the third most important.

Effects of Sample Preparation and Handling Methods on Quality Characteristics and Sucrose.--S. S. Martin and R. J. Hecker.

In previous years, analyses of various sugarbeet extracts for sucrose, purity and quality components have been made (see 1974 Report). Although one would not expect comparable numerical data from year to year, it was disturbing that the relative magnitudes of the components in the various juice types were not consistently maintained. We are using the analytical data to construct quality prediction models, and we have continued to examine the effects of sample type and handling methods on the measurement of sucrose and non-sucrose characters.

To assess the influence varying soil fertility might have on juice quality in different years, we examined the effect of two nitrogen fertility levels on quality component magnitudes in three extract types. The low N treatment consisted of no applied N, whereas the high N treatment was 200 lbs N/A, one-half applied preplant and one-half side-dressed after thinning. The three extracts were: (1) leaded sucrose filtrate; (2) laboratory thin juice; and (3) 1:1 extract of frozen brei. Results of this experiment are shown in Table 1. In the low N treatment, significant differences among the three extract types were found for potassium, total N, chloride, and betaine content. Under the high N conditions, two additional components, sodium and amino N, differed significantly among the extracts. In both N treatments, the 1:1 extract of frozen brei had the highest concentration, or was not statistically different from a numerically higher concentration, for every component except betaine, which was significantly higher in the sucrose filtrate. With few exceptions, the concentration of each component was higher in the high N extract than in the corresponding low N juice; the difference was statistically highly significant in every case but chloride, which showed no N-treatment effect for any of the three extracts, and potassium, which did not differ significantly between high N and low N treatments in the 1:1 frozen brei extract. Also, the N-treatment difference was significant only at the 5% level for betaine in the sucrose filtrates. More importantly, the relative order of concentration of the components was little changed between high N and low N treatments.

Sucrose content as percentage of beet fresh weight was measured in three extracts, and purity in two extracts, with the following results.

Juice extract type	Sucrose (% of fr wt)	
	Low N	High N
Sucrose filtrate, from fresh brei	18.40	16.36
Sucrose filtrate, from frozen brei	18.47	16.61
1:1 extract of frozen brei	18.64	16.80
	% Purity	
Laboratory thin juice	95.86	93.62
1:1 extract of frozen brei	96.67	93.37

As anticipated from other studies of nitrogen fertility effects, there were highly significant differences between N treatments for both purity and sucrose content of each extract type.

In another experiment 100 sugarbeet samples were extracted in several different ways, and the extracts split where necessary, for a study of the effects of sampling and sample storage procedures on purity and selected quality components. First, purity analyses showed highly significant differences among 4 methods of sample handling, with the highest purity in freshly analyzed pressed juice. If it is impractical to make purity determinations on freshly obtained pressed juice, it appears that freezing limed

Sample and handling procedure	% Purity
Limed juice, freshly analyzed	93.75 a
Limed juice, stored 14 days at 4°C	92.12 d
Frozen limed juice	93.38 b
Frozen brei, microwave thawed then juice expressed and immediately analyzed	92.75 c
	F = 1871***

juice for later analysis is the best alternative (dry ice quick-freezing was employed in this test). Microwave thawing of frozen brei is rapid and convenient, but because most microwave oven interiors have uneven patterns of energy distribution it is difficult to control defrosting in individual samples which may be irregular in shape. If freezing facilities are available, it does not seem wise to make purity measurements on refrigerated limed juice, at least if a refrigeration period as long as 14 days is required.

The split samples also were analyzed for sucrose content in three extract types. A standard fresh brei sucrose determination was made on each sugarbeet sample, and simultaneously another portion of the brei was quick-frozen with dry ice. Subsequently the frozen brei was microwave thawed, then analyzed either via the standard sucrose filtrate procedure or by preparing a 1:1 extract of the brei.

Extract	Sucrose % of fresh wt
Leaded sucrose filtrate from fresh brei	15.11 a
Leaded sucrose filtrate from frozen brei	14.72 b
1:1 extract of frozen brei, sucrose filtrate	14.77 b
	F = 7.78**

Both of the extracts from frozen brei show significantly lower sucrose concentrations than the fresh brei extract, leading to a suspicion that the

Table 1. Quality components in 3 sugarbeet extracts under 2 nitrogen treatments. Within each N-level, values followed by the same letter do not differ significantly by Duncan's multiple range test at the 1% level.

N treatment and extract type	mg/100 g sucrose						
	Na	K	NO_3	Amino N	Total N	Cl	Betaine
Low N							
1:1 extract of frozen brei	104.0 a	1651 a	39.8 a	190.9 a	1176 a	93.0 a	1691 b
leaded sucrose filtrate	133.4 a	1074 b	35.8 a	175.2 a	247 b	20.0 c	2112 a
laboratory thin juice	107.8 a	731 c	51.8 a	91.7 a	270 b	47.0 b	867 c
F	1.26 ns	226.4**	0.89 ns	2.02 ns	63.5**	81.6**	86.4**
High N							
1:1 extract of frozen brei	465.5 a	1532 a	233.4 a	461.0 a	1653 a	102.3 a	1780 b
leaded sucrose filtrate	385.3 ab	1383 a	212.2 a	340.2 b	453 b	21.3 b	2406 a
laboratory thin juice	215.1 b	927 b	179.3 a	174.0 c	447 b	50.1 b	947 c
F	7.2**	15.2**	0.58 ns	31.4**	38.3**	20.6**	46.9**

freezing-and-thawing procedure is resulting in a slight additional dilution.

Sucrose filtrate from each of the 100 sugarbeet samples was divided into 4 portions for a study of the effects of several methods of sample handling in the laboratory. The first subsample of each filtrate sample was immediately analyzed for sodium, potassium, and amino N, then it was refrigerated for 24 hours at 4°C and reanalyzed. Three other subsamples of each filtrate sample were immediately quick-frozen on dry ice and held at -20°C. Each set of subsamples was subsequently thawed by a different method and again analyzed for Na, K, and amino N. Each handling procedure was compared with the ideal condition, the freshly analyzed samples, by paired sample t-test, with the results shown in Table 2. The data suggest a problem in the analysis of these three important quality components in sucrose filtrates if fresh solution cannot be immediately analyzed. Sodium and amino N concentrations were significantly altered after 24 hours of refrigeration, whereas potassium content was unaffected. On the other hand, potassium concentration was significantly altered by freezing the sample, no matter what thawing procedure was employed, whereas sodium and amino N concentrations in samples that had been frozen were not significantly different from those of freshly analyzed samples.

Table 2. Paired-sample t-test values for freshly analyzed sucrose filtrate samples compared with identical subsamples handled by different procedures.

Freshly-analyzed samples compared with:	---paired sample t-test--- Na	K	Amino N
Fresh after 24 hrs at 4°C	2.27**	0.30 ns	6.75**
Frozen; thawed 18 hrs at 4°C	0.39 ns	5.91**	0.79 ns
Frozen; thawed in 37°C water	1.18 ns	6.79**	1.00 ns
Frozen; microwave thawed	0.78 ns	2.81**	0.28 ns

In the final experiment with the subdivided samples, sodium, potassium, and amino N were analyzed in three extract types, including the fresh brei sucrose filtrate discussed above, and two others prepared later from microwave thawed frozen brei. In one case, a 1:1 extract of frozen brei was analyzed immediately, and in the other a leaded sucrose filtrate prepared from the 1:1 extract was frozen and later microwave thawed for analysis. Each of the sample types based on extraction of frozen brei differed from

Extract	----mg/100 g sucrose--- Na	K	Amino N
1. Fresh brei sucrose filtrate	404 a	1102 a	180 b
2. 1:1 extract of frozen brei	363 ab	938 b	229 a
3. Sucrose filtrate from 1:1 extract of frozen brie; frozen then microwave thawed	342 b	953 b	195 b
	F = 4.73**	20.13**	9.10**

the fresh brei sucrose filtrate in content of two components, and the 1:1 extract leaded sucrose filtrate contained less amino N than did the 1:1 extract. In contrast to the more limited data of Table 1, potassium content was significantly greater in fresh brei sucrose filtrate than in either of the 1:1 extract sample types. Although the causes underlying these differences in extract means are not clear, correlation coefficients between the different extract types (Table 3) are sufficiently high to suggest that each extract closely reflects the others. Thus, it appears that useful quality component analyses can be made on any of several sample types, with the important qualification that extract preparation and the subsequent method of handling the samples must be standardized. The choice of extract type for quality measurements (at least of Na, K, and amino N) may be one of convenience, but data obtained from different extract types should not be directly compared numerically.

Table 3. Matrix of correlation coefficients for sodium, potassium and amino N among three sugarbeet extract types (numbered as in the preceding table).

	- - - - - - - - CORRELATION COEFFICIENT r - - - - - - - -								
	Sodium			Potassium			Amino N		
Extract	1	2	3	1	2	3	1	2	3
1	--	0.97	0.96	--	0.93	0.93	--	0.98	0.98
2		--	0.96		--	0.94		--	0.98
3			--			--			--

Experimental Hybrids Involving Rhizoctonia Resistant Pollinators.--R. J. Hecker and G. A. Smith.

In our program of breeding for rhizoctonia resistance, we need some information about the combining ability of lines developed in this program. We have used a diverse group of CMS lines and pollinated them with various of our lines bred for rhizoctonia resistance. The mean of all hybrids involving a specific pollinator provides a measure of the general combining ability of that pollinator. The performance of individual hybrids provides measures of specific combining ability.

The most superior hybrids in the test are listed in Table 1 below. None of the experimental hybrids were better than the checks. However, several of the hybrids merit further testing for potential use in production areas where rhizoctonia root rot is a problem. Entries 1384, 1353, 1373, 1345, and 1388 should have considerable resistance, and they have equalled or exceeded the sugar yield of the checks for 2 years at Fort Collins.

In Table 2 below are means of hybrids within pollinators, giving some information about the combining ability of the pollinators. The best pollinator was a Polish tetraploid. Among the rhizoctonia resistant pollinators, FC 703 is quite promising as a line from which to develop high combining resistant pollinators. With certain CMS's it may be useful as a pollinator without further combining ability improvement. FC 801, based on only two hybrids, needs to be tested more extensively. The merit of FC 702/5 is its consistently high sucrose and purity. A much larger number of experimental hybrids will be tested in 1976.

Table 1. Most superior experimental hybrids in the 1975 test of hybrids involving rhizoctonia resistant and other pollinators.

Entry no.	Hybrid	Root weight (T/A)	Sucrose (%)	Purity (%)	Recov. suc. (T/A)
1369	GW-918 X Polish 203/71 (4n)	23.2	14.0	90.0	2.592
1363	(562 CMS X 569) X FC 703	21.7	14.4	91.5	2.573
1355	(11866 X 12163) X FC 703	22.2	14.0	91.2	2.572
1384	E 929 X FC 702/4	21.1	14.5	90.8	2.500
1383	(652016s1 CMS X 622119s1) X FC 702/5	20.8	14.2	91.5	2.442
1353	9399-02 X FC 703	24.4	13.0	88.8	2.439
1373	H65-02-69 X Polish 203/71 (4n)	21.5	14.0	90.3	2.437
1345	9399-02 X FC 702/4	23.1	13.6	89.5	2.437
1360	681205H00 CMS X FC 702/2	20.2	14.4	91.6	2.431
1388	(11866 X 12163) X Polish 203/71 (4n)	21.7	14.0	90.3	2.427
1382	9399-02 X FC 703	23.8	13.1	89.0	2.422
1343	662119s1 CMS X FC 701/5	22.2	13.8	89.7	2.404
1380	662119s1 CMS X (FC 702/5 X FC 701/5, F_2)	23.3	13.2	89.8	2.402
1344	(100363 MS X 12166) X FC 703	20.6	14.3	90.9	2.396
1367	Mono Hy D2 (check)	22.7	14.5	92.0	2.739
1391	HH21 (check)	23.0	13.9	91.2	2.607
1389	Mono Hy A1 (check)	22.6	14.1	90.8	2.593
	LSD (0.05)	1.7	0.6	0.9	0.197

Table 2. Means of all experimental hybrids involving respective pollinators.

Pollinator	No. of hybs.	Root yield (T/A)	Sucrose (%)	Purity (%)	Recov.suc. (T/A)
Polish 203/71 (4n)	5	21.8±.41	14.0±.09	90.1±.4	2.437±.089
FC 703	11	21.2±.28	13.7±.06	90.6±.3	2.341±.060
FC 801	2	20.9±.65	13.6±.14	90.6±.7	2.311±.141
FC 702/5	5	19.7±.41	14.2±.09	91.4±.4	2.309±.089
FC 702/5XFC 701/5,F_2	5	20.5±.41	13.7±.09	90.3±.4	2.230±.089
FC 701/5	6	20.8±.38	13.6±.08	89.8±.4	2.218±.081

Effect of Polyploidy on Yield Components.--R. J. Hecker and G. A. Smith.

Part of our breeding methodology studies in 1975 consisted of a preliminary study to compare the sucrose yield and quality components among diploid and triploid hybrids as well as their diploid and tetraploid parents. The study is designed to determine and compare the relative magnitude of the effects of the non-sucrose components on purity, and of the yield components on sucrose yield. This information will help explain differences or similarities of different ploidy levels and could lead to sophisticated applications and methods in polyploid breeding to achieve higher sucrose production.

The mean of sucrose yield and its three components is shown in Table 1 below. This was a 22 replication field experiment designed as a randomized complete block. There were no large nor consistent differences in any characters due to ploidy among this small group of experimental populations. However, an examination of correlations within entries indicates that triploid hybrids 1403 and 1398 have similar correlations among characters, and both are different than 1405, yet the means of 1405 and 1403 are most similar. Hence, somewhat different component relationships may be interacting to result in similar means. A comprehensive experiment is planned for 1976 which, together with our 1975 experiment, will allow a critical analysis of differences due to polyploidy.

Table 1. Means for sucrose yield and its components at different ploidy levels.

Entry no.	Variety or description	Ploidy	Sucrose yield (T/A)	Root wt (T/A)	Sucrose (%)	Purity (%)
1405	H65-02-69 X Polish 203/71 (4n)	3n	2.99	22.5	15.6	93.0
1403	H65-02-69 X FC 703 (4n)	3n	2.94	22.7	15.1	92.9
1404	H65-02-69	2n	2.94	22.4	15.0	94.2
1402	H65-02-69 X FC 703	2n	2.87	22.2	15.1	92.8
1398	(11866 X 12163) X FC 703 (4n)	3n	2.80	21.4	15.3	93.0
1397	(11866 X 12163) X FC 703	2n	2.76	21.3	15.2	92.9
1399	11866 X 12163	2n	2.50	18.4	15.4	94.3
1406	Polish 203/71 (4n)	4n	2.48	18.8	15.6	92.4
1400	FC 703	2n	2.29	16.9	15.7	93.1
1401	FC 703 (4n)	4n	2.15	16.6	15.4	92.6
1395	HH-21 (check)	2n	2.92	22.4	15.3	92.8
	LSD (.05)		0.17	1.2	0.2	0.3

SUGARBEET RESEARCH

1975 Report

Section D

North Dakota Agricultural Experiment Station, Fargo, North Dakota

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Cooperation:

American Crystal Sugar Company
Minn-Dak Sugar Cooperative
Minnesota Agricultural Experiment Station
North Dakota Agricultural Experiment Station
Sugarbeet Research and Education Board of
Minnesota and North Dakota

The research was supported in part by funds provided through the Sugarbeet Research and Education Board of Minnesota and North Dakota

CONTENTS

SUGARBEET DISEASE RESEARCH

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Sugarbeet Storage Rot in the Red River Valley, 1974-75

Each season rot of sugarbeets in storage accounts for losses of sugar. Estimates of the amount of this loss have not been based on sample data. Our objectives were to sample and examine roots as they began the factory process, to determine the amount of rotted tissue, identify the causal pathogens and, on the basis of the data, to estimate losses in the Red River Valley.

The survey was made from November 6, 1974, through March 12, 1975, at the American Crystal Sugar Company factory, Moorhead, MN. Samples were removed from the picking table on alternate days. Two samples were taken at randomly selected 12-h intervals on each sample day. Sample size was a standard tare bag of 10-17 kg (22-37 lbs). Samples from 6 factories in the Red River Valley were compared on January 24, 1975. During a 10-minute period four samples were obtained at the picking table of each factory.

The roots were returned to the laboratory, weighed, quartered longitudinally, divided into topping classes, and the decayed portions removed and weighed. Frozen tissue also was removed and weighed. The roots were classified into those with no crown tissue removed, all crown tissue removed, or partial crown removed. Rotted or frozen tissue was expressed as percent by weight. The tons of rotted tissue that were processed daily was determined by multiplying the percent rot derived from the sample times the tons of production for that particular day. This same sample percent also was used for estimating rot on the following day when no sample was taken.

Rotted tissues from the crown, pith, body, and tail of the root were examined for pathogens. Rotted tissue samples of uniform size were removed with a cork borer and eight slices from each portion of the root were plated on potato-dextrose agar.

When this survey began on November 6, 1974, 10 tons of rotted sugarbeet tissue was being processed daily at Moorhead. The daily tonnage of rotted root tissue that was sliced gradually increased to nearly 100 tons at the end of the campaign (Fig. 1). The amount of rotted sugarbeet tissue that entered the factory during the 128-day survey period was 1.22% of the total tons that were processed. Of this amount, 0.18% was body, 0.20% tail, 0.36% crown, and 0.58% pith tissue. During the early part of the survey much of the rot tended to be associated with wounds on the tap root. The amount of rot remained low in the tap root and tail portions, but increased in the crown and pith as the season progressed. Rot was 1.5 times as great in pith as in crown tissue.

A 1-day comparison among the six factories showed the amount of rot ranged from 0.5 to 2.1% by weight with no statistical difference (Table 1).

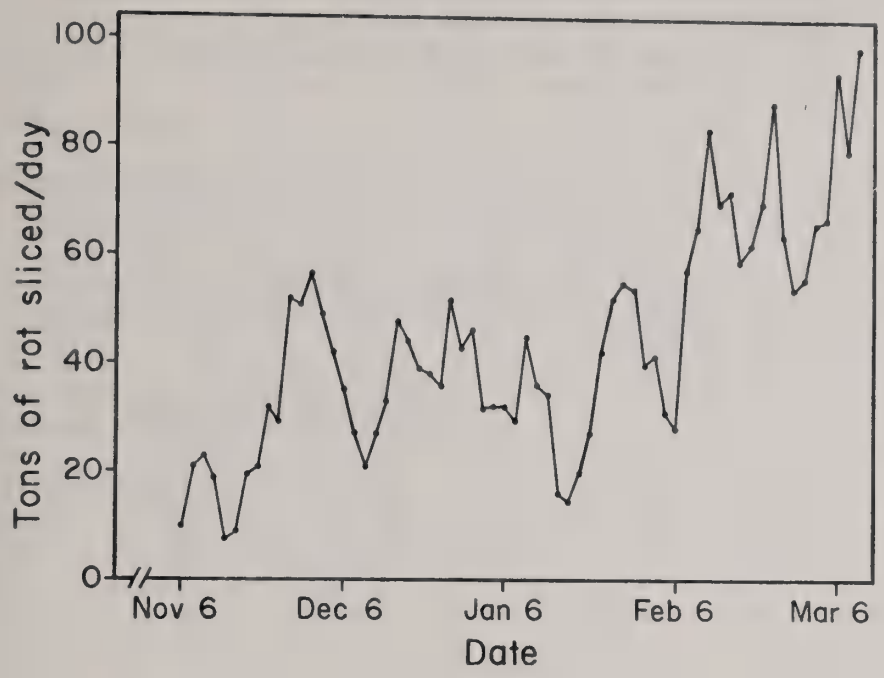

Fig. 1. Running average of daily rot sliced at Moorhead factory.

Table 1. Topping classification, frozen tissue, and decay in beets selected from the picking tables of six factories on January 24, 1975.

Factory	Crowns removed (% of roots)			Percent by weight	
	None	Partial	All	Frozen	Decay
	%	%	%	%	%
Hillsboro	11[a/]	83	6	55	2.0
Drayton	16	82	2	51	0.7
East Grand Forks	13	79	7	8	1.2
Crookston	14	78	8	58	0.5
Wahpeton	10	86	5	86	2.1
Moorhead	19	75	6	12	1.5
Mean	14	80	6	45	1.2
LSD 0.01	ns	ns	ns	28	ns

a/ Average of four 1-bag (10-17 kg) samples.

Phoma betae and Penicillium claviforme were the most prevalent pathogens. P. betae was more abundant than P. claviforme in pith tissue, but the prevalence of both fungi was comparable in other rotted tissues. Incidence of Fusarium spp. was much lower than of Phoma or Penicillium. Botrytis cinerea Pers. was least frequent and was restricted to pith, crown and body tissue (Table 2).

The frequency of roots with different amounts of crown tissue removed did not differ during the sampling period. Of the 2,246 roots examined from Moorhead, 23% had no crown removed, 6% had all the crown removed, and 71% had part of the crown removed. Data from individual factories were similar (Table 1).

The average amount of frozen tissue processed was 34% for the entire sample period but, on a daily basis, approached 75% at the end of the campaign.

Table 2. Prevalence of four storage rot pathogens in stored sugarbeets determined by plating rotted tissue of roots entering a Moorhead factory from 2 December 1974 through 12 March 1975.

	Percent of plated tissue			
	Pith	Crown	Body	Tail
Phoma betae	32	23	12	10
Penicillium claviforme	21	18	14	18
Fusarium spp.	4	8	8	11
Botrytis cinerea	0.4	0.9	1	0

Total pieces plated: 2,656.

To our knowledge, this is the first estimate in the United States of losses of sugarbeets from decay that has been based on sample data. From these loss data, we have estimated the loss of sugar caused by the decay of sugarbeets. During the 128-day survey period, 456,820 tons of sugarbeets were processed at the Moorhead factory. This tonnage times 1.22% equals 5,583 tons of rot, having a potential sugar yield of 1,113,240 lb. The reducing sugars that resulted from the inversion of sucrose in the rotted tissue probably carried another 1,781,184 lb of sucrose into molasses (1.6 melassigenic factor). Therefore, the total sugar loss was estimated at 2,894,424 lb. Sugar losses probably were comparable at the other five factories in our region. The total sugar loss for the Red River Valley then could be estimated at 17,366,544 lb. At 20-45 cents per pound the loss would represent $3,473,308 to $7,814,945. This loss also could be expressed as 0.0495 lb of sugar lost/ton/day, or 10% of the 0.5 lb/ton/day loss which is considered average for our region.

These results support earlier observations that P. betae is the most important pathogen that causes decay of sugarbeets in the Red River Valley. The newly recognized pathogen P. claviforme was nearly as prevalent at P. betae but does not decay root tissue as rapidly as P. betae. The low incidence of B. cinerea probably was due to the antagonistic ability of P. claviforme.

Partially crowned roots decay faster than uncrowned or completely crowned roots because the exposed pith tissue is very susceptible to attack by P. betae. This survey has shown that 71% of the roots examined were partially crowned and that rot in the crown and pith was 2-6 times as great as in the tail or body. This suggests sugar loss from decay might be reduced if the roots were uncrowned.

A Russian report more than 35 years ago referred to the susceptibility of the central core of the crown and suggested that crowns be cut cone-shaped rather than straight across to reduce losses from storage rot.

Antagonism of Penicillium claviforme toward Botrytis cinerea

Phoma betae and Botrytis cinerea cause storage rot of sugarbeets. In England, Russia, and western U.S.A, B. cinerea was considered as important as Phoma betae. One report from Canada listed P. betae, not B. cinerea, as the most prevalent storage rot pathogen. Botrytis cinerea was not prevalent on stored sugarbeets in the Red River Valley of North Dakota and Minnesota during the last four years. In a survey of roots collected at a factory during the 1974-75 processing season, P. betae was isolated from 19% and B. cinerea from only 0.6% of the rotted tissue.

Penicillium claviforme recently has been recognized as a pathogen of stored sugarbeets. This fungus was present in 18% of the plated tissue described above and is an antagonist of B. cinerea. This antagonistic behavior may partially account for differing reports of the prevalence of B. cinerea so experiments were conducted to test this hypothesis and the results are reported here.

The antagonism of P. claviforme was tested against P. betae and B. cinerea in sugarbeet tissue. Cores 18 mm in diameter and about 6 cm long were taken from roots and placed on end in 80 x 100 mm petri dishes. The dishes contained single spore agar cultures of each fungus alone or P. claviforme mixed with B. cinerea or P. betae. Cultures with B. cinerea were incubated 9 days and P. betae 11 days at 22 C; the cores were then cut longitudinally and rated for the distance rot had progressed along the core. Rating: 0 = 0 mm; 1 = 1-5 mm; 2 = 6-10 mm; 3 = 11-15 mm, etc. Inoculation treatments were replicated three times with four cores per replicate.

When P. claviforme was combined with B. cinerea or P. betae on root tissue, there was complete inhibition of rot caused by B. cinerea, but very little effect on rot caused by P. betae (Table 1). The amount of decay in the Penicillium-Botrytis treatment was not greater than that of Penicillium alone. In the Penicillium-Phoma treatment, the amount of decay was similar to Phoma alone.

Inhibition also occurred in liquid culture. The mycelial dry weight of B. cinerea when grown in Czapek's solution was 167 mg. When grown in culture filtrate of P. claviforme that had been diluted 2, 10, 100, 1,000, and 10,000 times, the mycelial dry weight was 10, 80, 65, 47, and 58 mg, respectively; LSD (P = 0.01) 11. Even at the highest dilution, growth was retarded more than 50% compared to the control. Growth in the dilution series was highest in the 1:10 dilution instead of in higher dilutions, indicating a stimulatory effect.

This P. claviforme and B. cinerea association is an unusual situation in which two pathogens compete for the same host. In this case, the less virulent pathogen dominates because it is antagonistic toward the more virulent pathogen.

The greater prevalence of P. claviforme over B. cinerea in the factory survey may be partially due to this antagonism. An abundance of P. claviforme but not B. cinerea was also observed on stored sugarbeets in Washington (personal observation).

Table 3. Rot produced on sugarbeet roots (cores) by combined or single inoculation with Penicillium claviforme, Botrytis cinerea, and Phoma betae.

Inoculum	Rot index[b/]
Botrytis x Penicillium[a/]	1.8
Phoma x Penicillium	3.3
Penicillium alone	1.8
Botrytis alone	3.2
Phoma alone	3.4
LSD (P = 0.01) 0.9	

a/ Two other single spore isolates of P. claviforme gave similar results.
b/ Rot index based on distance decay progressed along a core of root: 0 = 0 mm; 1 = 1-5 mm; 2 = 6-10 mm; 3 = 11-15 mm; 4 = 16-20 mm, etc.

A recent development in the storage of sugarbeets is the use of buildings or protective covers to reduce damage caused by freezing, thawing, and desiccation. Air is recirculated to maintain proper temperatures within these structures. This is a favorable situation for dissemination of air-borne conidia of Penicillium and Botrytis. The prevalence of P. claviforme on stored sugarbeets within rigid structures in Washington suggests that decay caused by this pathogen might be greater within a closed system than in open storage.

Penicillium claviforme may interfere in screening tests. Care should be taken to reduce contamination by P. claviforme, which our experience has shown can ruin a test designed to select roots for resistance to B. cinerea.

Caution also should be exercised in the use of fungicides on stored sugarbeets. If P. claviforme is controlled but not B. cinerea, decay could still proceed and might even be more severe than if a fungicide was not used because of the greater virulence of B. cinerea over P. claviforme.

Powdery Mildew

Powdery mildew was in Red River Valley sugarbeet fields for the first time in 1975. Fortunately, the infection began late in the growing season and losses were minimal. Research at other locations in the U.S. shows that this fungus does not survive through the winter. Nevertheless, we must determine if this fungus will survive our winters. Mature sugarbeet leaves and seedstalks are more susceptible than seedlings or young leaves. So plants will be grown in the greenhouse this winter, then transplanted in May to fields that were heavily mildewed in 1975. If this older tissue becomes infected early in the season it will indicate that the inoculum has overwintered. Overwintered inoculum will account for infection beginning about mid-July to early-August in which case sulfur must be applied. Wind-blown inoculum from southwestern U.S. would be expected to cause infection about the same time as in 1975.

Developments in Breeding for Resistance to Storage Rot

About 2,100 roots of new introductions and advanced lines were evaluated during the winter of 1974-75 for resistance to Phoma betae and Botrytis cinerea; selections were made from Russian introductions described as resistant to storage rot. The best Russian entry expressed resistance in 50% of the roots to Phoma or Botrytis. Occasional roots were resistant to both pathogens. Selections from four of the most promising entries have been added to our improvement program.

In the storage season of 1974-75, two of our most advanced lines possessed resistance to Phoma in 28% and 87% of the roots. This storage season, 4,119 roots have been evaluated for resistance to Penicillium claviforme in addition to P. betae and Botrytis cinerea. The results have not been analyzed but an increase in the prevalence of roots resistant to Phoma does not appear to be appreciable. Progress has been made with Botrytis. Roots resistant to P. claviforme were scarce--there is much room for improvement.

Abstracts of manuscripts approved for publication:

1. Bugbee, W. M. 1975. Penicillium claviforme and Penicillium variabile: Pathogens of stored sugarbeets. Phytopathology 65:926-927.

   Penicillium claviforme and P. variabile were identified as pathogens of stored sugar beets. P. claviforme was more pathogenic than P. variabile, but less pathogenic than Phoma betae or Botrytis cinerea at 5 or 20 C. P. claviforme was more prevalent than P. variabile. The distinctive coremia of P. claviforme aided in identification, both in culture plates and storage piles.

2. Bugbee, W. M. and E. H. Lloyd. 1975. Sugarbeet storage rots in the Red River Valley. N. D. Extension Service Fact Sheet describing, with color photos, decay caused by Phoma betae, Penicillium claviforme, and Botrytis cinerea.

3. Cole, D. F. 1975. Changes in leaf area and specific leaf weight of sugarbeet leaves during the growing season. Crop Sci. 15:882-883.

   The purpose of this investigation was to observe the rate of leaf accretion and changes in specific leaf weight (SLW) of sugarbeet leaves initiated during the latter portion of the growing season. Leaves increased in area at a rapid rate during the first 14 days after leaf emergence. Specific leaf weight changed as the leaves expanded in area. Diurnal changes in SLW may be related to changes in temperature, incoming radiation, or translocation rates. Leaves initiated late in the growing season were smaller and had a higher SLW than leaves initiated earlier in the growing season.

4. Cole, D. F. Effect of cultivar and mechanical damage on respiration and storability of sugarbeet roots. Accepted for publication in J. Am. Soc. Sugarbeet Technol. Oct. 31, 1975.

   The objectives of this investigation were to compare sugarbeet cultivars and to determine the effect of mechanical damage on respiration and storability of sugarbeet roots. Sugarbeet roots of commercial cultivars were grown in a silty clay soil and stored at 5 C and near 100% relative humidity for 150 days. Respiration rates were measured using gas chromatographic techniques.

   Commercial cultivars used in the Red River Valley differed in respiration rates each year, and with the cultivar tested there was no significant time in storage by cultivar interaction either year. Respiration rates increased during storage. Cultivars differed in sucrose content and sucrose decreased with storage time.

   Respiration rates of sugarbeet roots were significantly affected by the level of mechanical damage during harvest and piling of the roots for storage. Invert sugars increased as the amount of damage to the sugarbeet root increased during harvest and storage.

   The results indicate that cultivars and mechanical damage during harvest can significantly affect respiration rates during post-harvest storage.

SUGARBEET STORAGE RESEARCH

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Effect of Cultivar and Mechanical Damage on Respiration and Storability of Sugarbeet Roots

Sucrose loss during post-harvest storage of sugarbeet roots is a major concern of the sugarbeet industry. During post-harvest storage, sucrose losses can amount to 0.5 lb/ton/day. Sucrose is lost during storage through respiration, raffinose synthesis, storage pathogens, and inversion to glucose and fructose. Further sucrose loss during processing increases with storage due to an increase in raffinose and invert sugars which causes an increase in the melassigenic factor.

Respiration by the sugarbeet root accounts for 50 to 60% of the sucrose loss during post-harvest storage. Storage pathogens account for 10% of the loss in sucrose during storage in the Red River Valley of North Dakota and Minnesota. The objectives of this study were to compare sugarbeet cultivars and to determine the effects of mechanical damage during harvest on respiration and storability of sugarbeet roots. Commercial cultivars were grown in a silty clay soil and stored at 5 C and near 100% relative humidity for 150 days. Respiration rates were measured using gas chromatographic techniques.

Cultivars differed in respiration rates each year and with no significant time in storage by cultivar interaction either year (Table 1). Respiration rates increased during storage. Cultivars differed in sucrose content and sucrose decreased with storage time.

Table 1. Respiration rates of sugarbeet cultivars during two storage periods.

*Cultivar	Storage period †1973-74	‡1974-75
	ml CO_2 kg^{-1} hr^{-1}	
American 4 Hybrid A	1.69	2.65
American 2 Hybrid B	2.06	2.44
American 4 Hybrid T	2.16	-
Holly HH 21	-	2.11
Beta 93	1.74	1.96
Beta 1224	-	1.81
Bush-Mono	1.68	-
Mono-Hy D2	1.68	1.70
LSD 0.05	0.16	0.14

* Average of 6 samples of each cultivar
† Averaged over 5 sampling times from 75 to 146 days after harvest.
‡ Averaged over 8 sampling times from 53 to 150 days after harvest.

Respiration rates of sugarbeet roots were significantly affected by the level of mechanical damage during harvest and piling of the roots for storage (Table 2). Invert sugars increased as the amount of damage to the sugarbeet roots increased during harvest and storage.

The results indicate that cultivars and mechanical damage during harvest can significantly affect respiration rates during post-harvest storage.

Table 2. Respiration rates of sugarbeet roots during two storage periods of 150 days duration subjected to various mechanical operations during harvest.

Treatment*	Storage period 1973-74	1974-75
	ml CO_2 kg^{-1} hr^{-1}	
1	1.99†	1.57‡
2	2.06	1.79
3	2.32	2.04
4	2.47	1.88
LSD 0.05	0.22	0.13

* 1) Control, non-topped, lifted manually; 2) mechanically topped, lifted manually; 3) topped and lifted mechanically, obtained off truck in 1973 and roots dropped to ground in 1974; 4) collected after piling.
† Averaged over 5 sampling times from 53 to 146 days after harvest.
‡ Averaged over 10 sampling times from 40 to 150 days after harvest.

Factors affecting internal CO_2 concentration in sugarbeet roots

Studies were conducted to determine if there was genetic variation in internal CO_2 levels in sugarbeet roots and to determine the effects of resident bacteria, storage temperature, decay, and root weight on internal CO_2 levels. Significant differences in internal CO_2 levels were observed among different germplasm sources (Table 4). Internal CO_2 levels of roots selected from American 3 Hybrid T were not correlated with the number of resident bacteria or weight of the roots after two storage periods (Table 3). Internal CO_2 levels in roots with visible decay were significantly higher (272%) than CO_2 levels in healthy roots. Storage temperature significantly affected internal CO_2 levels in sugarbeet roots (Fig. 1). Our results show that there is genetic variation for internal CO_2 levels in sugarbeet roots and that internal CO_2 levels appear to be related to respiratory activity.

Table 3. Correlation coefficients between internal CO_2 and various parameters measured on roots of American 3 Hybrid T stored for 67 and 160 days at 5 C and near 100% relative humidity.

Time in storage, days		Weight	Bacteria SH*	Bacteria NH**	Bacteria Total
67	CO_2, %	0.15	0.07	0.10	0.10
160	CO_2, %	-0.03	-0.06	0.03	0.00

* Capable of hydrolyzing sucrose.
** Not capable of hydrolyzing sucrose.

Table 4. Internal CO_2 levels of sugarbeet roots of various entries grown at Fargo, ND, in 1974 and stored at 5 C for 100 days.

Entry	Selection criteria*	n	Internal CO_2 %	Entry	Selection criteria*	n	Internal CO_2 %
SR 7312-2	D	4	2.915	653	A,B	20	1.645
FC 731068	C	31	2.375	645	A	12	1.598
650	D	15	2.288	F738	D	5	1.565
SR 7420-1	D	5	2.227	637	A,B	22	1.552
FC731097H	C	14	2.151	634	A	9	1.526
SR 7426-1	E	4	2.119	654	A	22	1.481
Acc 2773	C	13	2.041	SR 7428-1	D	4	1.431
651	D	22	1.974	640	A	11	1.414
FC711245H00	B	9	1.908	641	A	10	1.377
649	A	25	1.875	SR 7411-1	E	6	1.367
F510	D	10	1.817	F505	D	8	1.348
SR 7410-1	E	7	1.804	652	A	4	1.347
FC711006-0	C	16	1.783	A73-13	A	16	1.334
SR 7425-1	E	5	1.783	633	A	4	1.317
F526	D	7	1.777	636	A	19	1.316
FC721048H0	B	6	1.755	643	A	6	1.315
635	A,B	8	1.754	646	A	5	1.306
FC 721049H0	C	13	1.751	639	A,B	7	1.288
647	A	15	1.706	638	A,B	4	1.284
SR 749-1	E	4	1.704	644	A	4	1.260
648	A	19	1.679	642	A	8	1.255

LSD 0.05 = $\sqrt{0.17334(\frac{1}{ni} + \frac{1}{nj})}$ X 1.960

* A = Commercial cultivar, B = selected for foliar disease resistance, C = selected for field root and crown disease resistance, D = selected for storage rot resistance, E = experimental crosses.

Changes in resident bacteria, pH, sucrose, and invert sugar levels in sugarbeet roots during storage

Internal tissues of various fruits, vegetables, and sugarbeet roots contain numerous bacteria, some of which are plant pathogens.

In the Red River Valley of North Dakota and Minnesota, sugarbeet (Beta vulgaris L.) roots are stored in open piles for up to 150 days after harvest. In commercial sugarbeet storage piles, localized increases in temperature of the piles are often observed, which are called "hotspots". This temperature increase is usually associated with a blockage of natural air circulation through the pile, which is necessary for heat to dissipate from the roots.

Hotspots usually increase during storage, even under ambient air temperatures as low as -35 C. Visual examination of the sugarbeet roots located in a

hotspot shows evidence of bacterial growth, and the air around the hotspot has a characteristic odor similar to silage, symptoms which suggest fermentation.

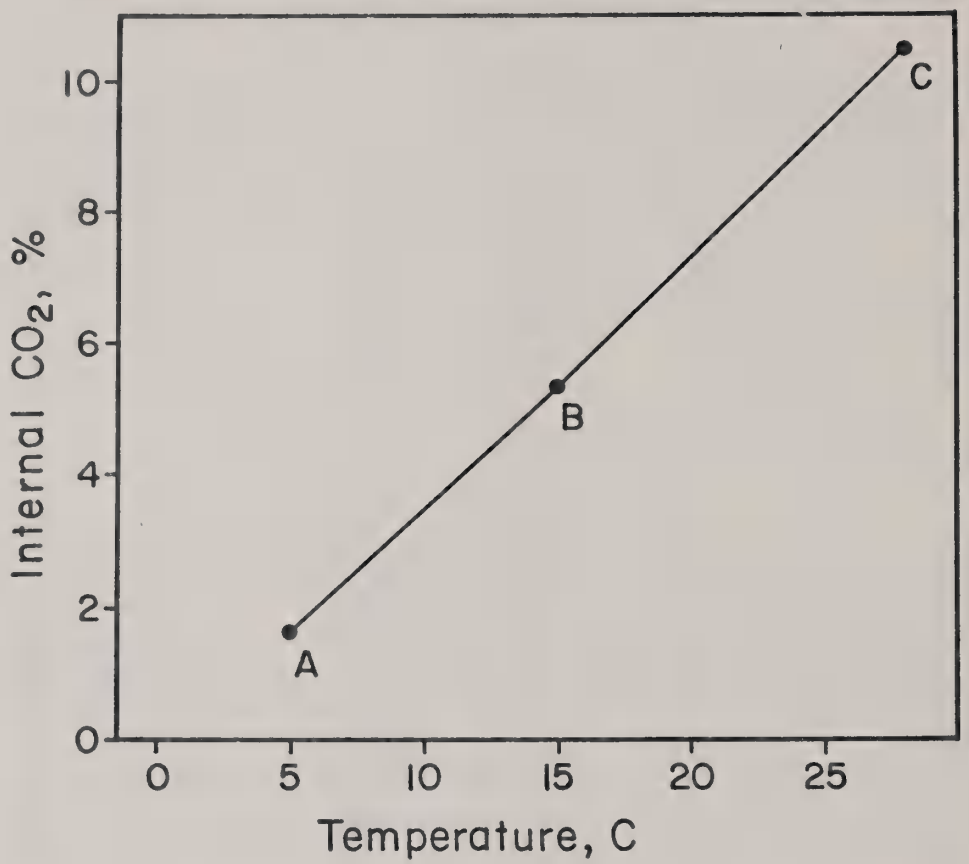

Fig. 1. Effect of temperature on internal CO_2 level of sugarbeet roots. Points followed by the same letter are not significantly different at the 0.05 level according to Duncan's multiple range test.

Our objectives were to compare resident bacterial populations, invert sugars, and pH changes with sucrose loss in sugarbeets stored aerobically and anaerobically at different temperatures.

Sugarbeet roots were selected from an area of a commercial storage pile which appeared normal after 130 days storage in 1974 to 1975, washed, and sorted into about 12-kg samples. Twelve root samples were placed into perforated bags; 12 were placed into 27.2 liter pails, and 2 samples were used to establish sucrose content at day 0. Bacterial populations of the sugarbeet roots were determined as described by Dr. Bugbee in the 1974 Sugarbeet Research Report.

All samples in bags and open plastic pails were stored at either 5 or 26 C for 2 days, after which O_2 levels of the sugarbeet roots and of the surrounding air were determined by gas chromatography. The pails were then sealed and oxygen depletion was monitored for 4 to 5 days. Two different pails and two different bags were sampled at 7, 14, and 21 days after oxygen was depleted in the pails at 26 C, and at 14, 21, and 28 days after oxygen was depleted at 5 C. At each sampling date for roots stored at 26 C and day 28 for roots

stored at 5 C, cores were removed from the same roots as day 0 to determine the change in pH, invert sugars, and resident bacteria. At each sampling date pulp was obtained with a multiple blade saw from all beets in a pail or bag and analyzed for sucrose content. After pulp was obtained, the roots were discarded.

The experiment was repeated during the spring of 1975 using freshly harvested roots from California. In the second experiment an additional treatment was included (anaerobic storage at 15 C).

At the beginning of the experiment, atmospheric O_2 levels were normal (20.7%) in the open plastic pails and perforated plastic bags. The roots had similar O_2 levels in the plastic pails and plastic bags at the same temperature. However, the roots had an O_2 level of 19.3% at 5 C, but a level of only 13.5% at 26 C. This indicates that O_2 is used faster at the higher temperature.

Chamber oxygen was depleted in less than 24 hours at 26 C after the pails were sealed (Fig. 2 and 3A). At 5 C, oxygen was depleted more slowly. Oxygen uptake rate at 26 C decreased as oxygen levels decreased; however, O_2 uptake rates at 5 C were not affected until oxygen levels in the pails dropped below 5% (Fig. 2 and 3). Rate of O_2 uptake and chamber O_2 depletion at 15 C was intermediate to the rates at 26 and 5 C (Fig. 3).

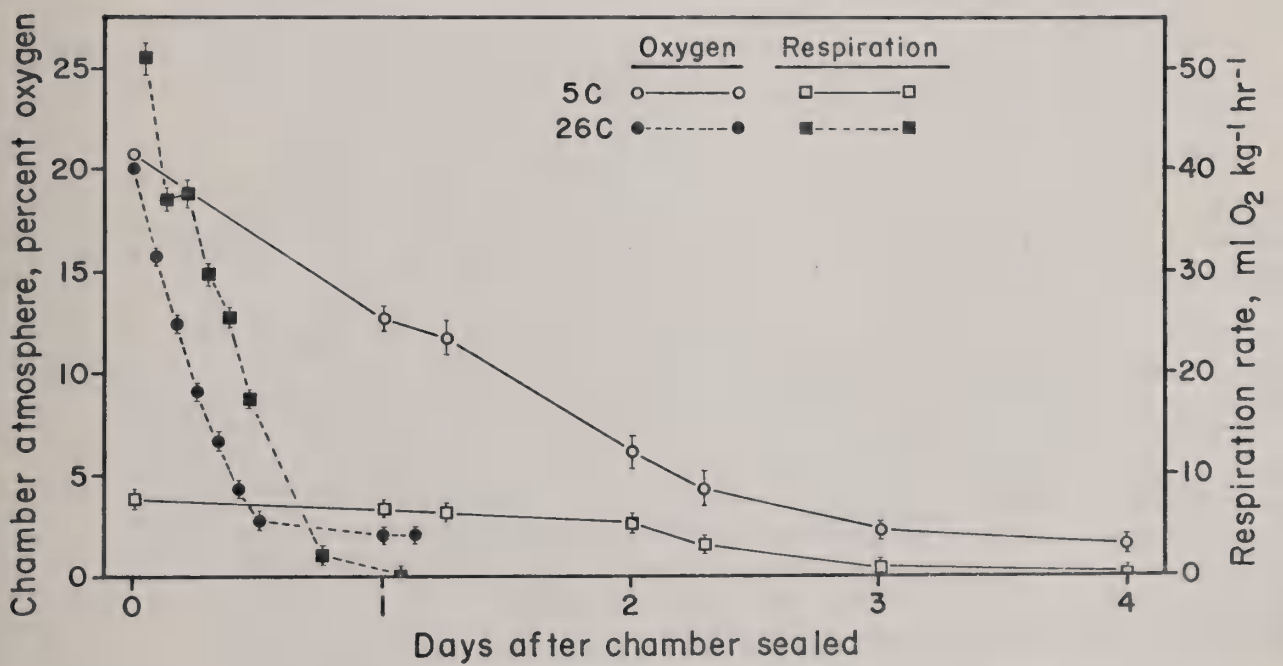

Fig. 2. Changes in atmospheric O_2 levels and O_2 uptake rates of sugarbeet roots from commercial storage pile stored in pails at 5 and 26 C. Vertical bars represent standard error of the mean.

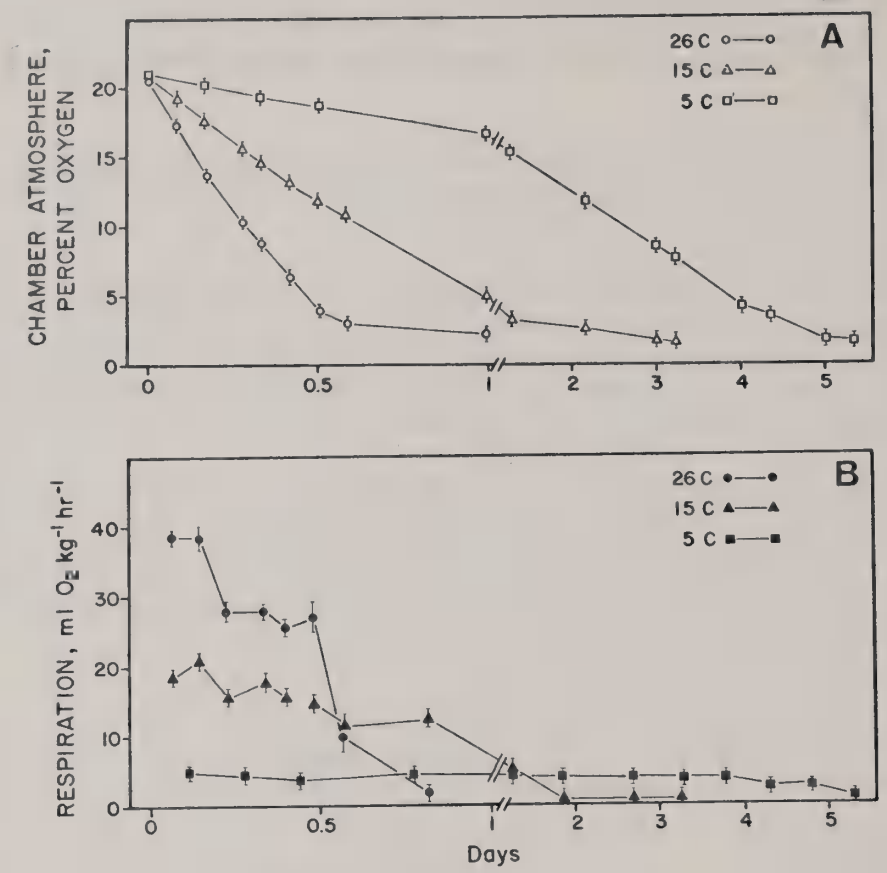

Fig. 3. Changes in atmospheric O_2 levels (A) and O_2 uptake rate (B) of sugarbeet roots at 5, 15, and 26 C. Roots selected from freshly harvested roots. Vertical bars represent standard error of the mean.

Number of bacteria capable of hydrolyzing sucrose in vitro before aerobic and anaerobic storage of the roots was less than 10% of total bacteria present. After O_2 was depleted at 26 C, the total number of bacteria increased rapidly (Fig. 4), and after anaerobic storage for 7 days at 26 C, most bacteria present in both commercially stored and fresh roots was capable of hydrolyzing sucrose in vitro (Tables 5 and 6). Under aerobic storage at 26 C, sucrose-hydrolyzing bacteria increased between 14 and 21 days in beets stored for 130 days (Table 6). However, no change in hydrolyzing bacteria was detected in fresh roots aerobically stored, but the number of nonhydrolyzing bacteria increased (Table 6).

Invert sugar levels in the roots stored under anaerobic conditions increased at 26 C (Fig. 4). Roots stored under aerobic conditions changed little in invert sugar levels, except those stored 21 days at 26 C (Fig. 4A). These roots began to show decay from storage fungi and their bacteria levels increased (Table 5).

Under anaerobic conditions, the pH of the core juice from commercially stored and fresh sugarbeets declined significantly as the number of bacteria increased in the juice (Fig. 4). The decrease in bacterial counts may have resulted from a decrease in available substrate or from growth inhibition from the low pH.

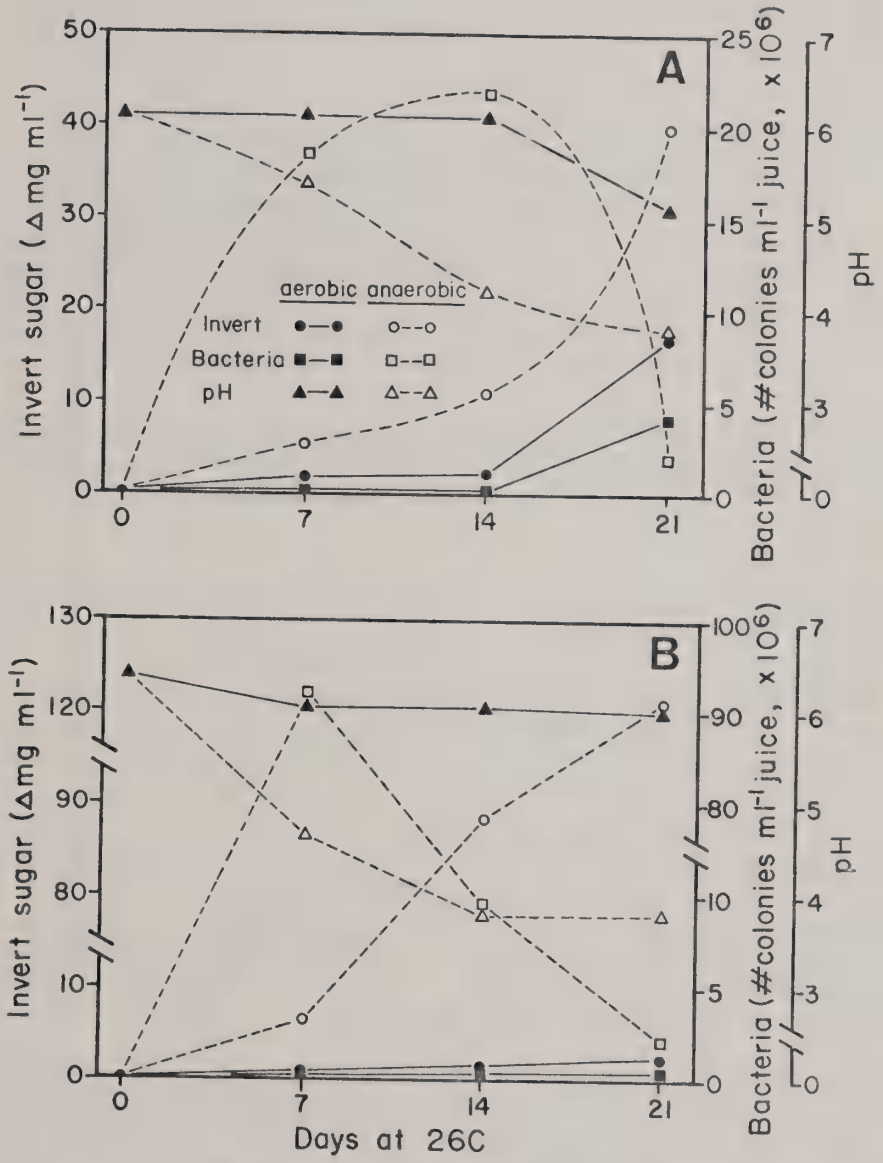

Fig. 4. Changes in invert sugar, resident bacteria, and pH of sugarbeet juice from roots stored under aerobic and anaerobic conditions at 26 C for 21 days. A. Cores from roots selected from commercial storage pile. B. Cores from freshly harvested roots.

Sucrose content of pulp from the roots decreased as the number of bacteria increased (Fig. 4 and 5) under anaerobic storage. Apparently, during anaerobic storage, sucrose was hydrolyzed by the bacteria. Some acid hydrolysis may also have occurred, especially after the pH decreased below 4.5. Higher temperatures and a pH of 4.5 are used in the commercial production of invert sugar from sucrose.

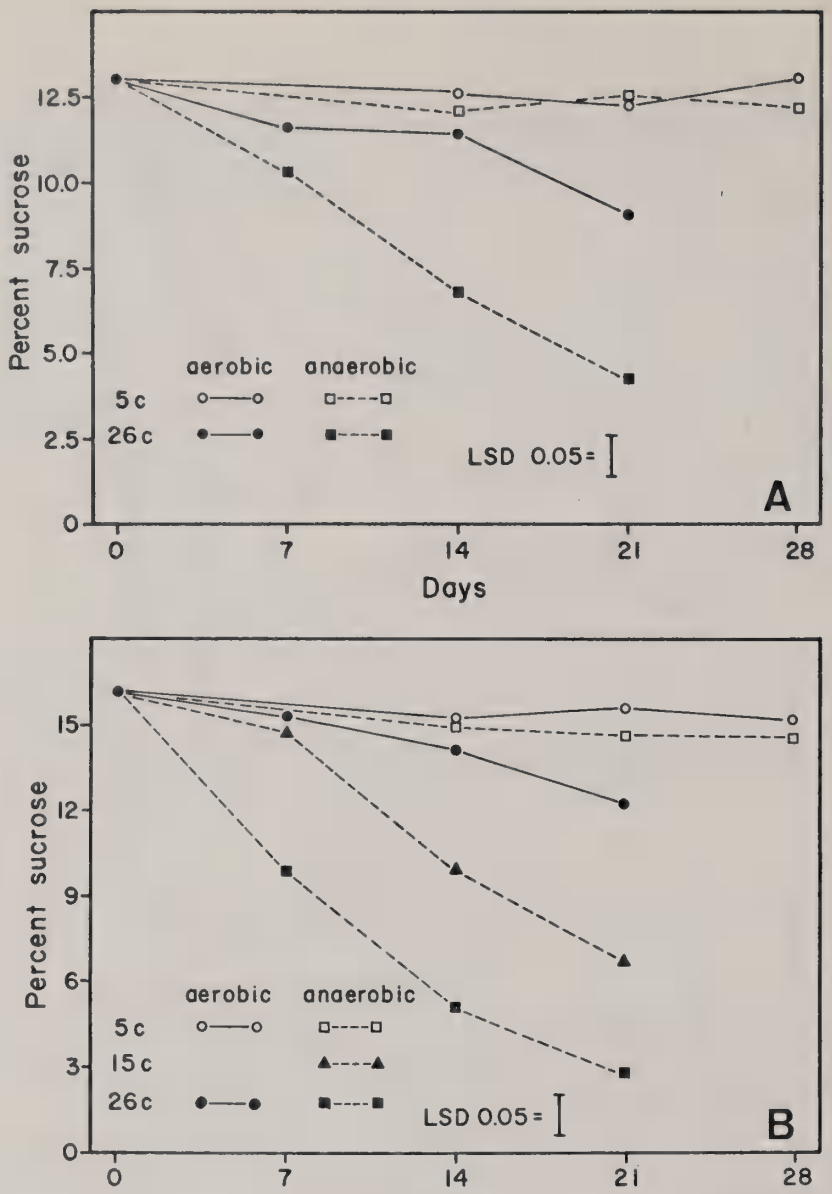

Fig. 5. Changes in percent sucrose of sugarbeet roots stored under aerobic and anaerobic conditions at 5 and 26 C. A. Roots selected from commercial storage pile. B. Freshly harvested roots.

Our data suggest that O_2 depletion will activate internal bacterial populations and that the bacteria present in sugarbeet roots could completely deplete sucrose in 21 days at 26 C under anaerobic storage conditions. This indicates that air movement in commercial sugarbeet storage piles is important early in the storage, since fermentation can begin within 24 hours after oxygen is depleted. Although the sugarbeet roots in this investigation did not appear excessively deteriorated after 21 days of anaerobic storage at 26 C, they were almost completely lacking in sucrose. This may explain why factory sucrose extraction decreases when beets from a hotspot are processed.

higher in impurities and lower in sucrose when compared to the main body of the sugarbeet root. The crown is the area above the lowest leaf scar. However, there are data which indicate that more sugar per acre can be recovered from beets which are only flailed before harvesting. This increase can come about for several reasons: (a) sugar can be extracted from the crown material, (b) respiration losses would be reduced by not cutting the crown, and (c) the amount of rot would be reduced by not exposing the most susceptible tissue, which is the center portion of the crown.

If sugarbeets were only flailed at harvest, an increase in tonnage and a reduction in sucrose content would be expected. However, no data is available to indicate the change in either tonnage or sugar content. A survey at one location in the Red River Valley in the 1974-75 processing campaign indicated that only 6% of the sugar beets were topped at the lowest leaf scar, 71% were partially topped, and 23% were only flailed. This data indicates that a considerable amount of crown tissue is being processed at the present time.

A survey of commercial sugarbeet growers was conducted during the week of September 29 to October 3, 1975, in the Red River Valley of North Dakota and Minnesota to determine the change in tonnage and root quality if sugarbeets were only flailed.

Sugarbeet samples were obtained from growers selected at random in each factory district in the Red River Valley. Four ten-beet samples were harvested from each grower and/or location in a field. In each field tested, samples were obtained from adjacent rows where the grower had temporarily stopped scalping. From the row which had not been flailed or scalped, two ten-beet samples were manually harvested. The leaves were removed at the base of the petiole with a knife. The crowns were then removed at the lowest leaf scar on one sample and weighed. The 10 roots were then placed into a 'tare bag' for further analysis. The other 10-beet sample was also placed into a 'tare bag'. Two 10-beet samples were manually harvested from the adjacent row where the grower had flailed and scalped the sugarbeets. The remaining crown tissue on one sample was removed and weighed. Roots of both samples were placed into 'tare bags'. Length of row harvested for each 10-beet sample was determined. Sixty-eight locations were sampled. Flailed samples were obtained from an additional 6 fields in the East Grand Forks, Minnesota, area. Grower-scalped samples were not obtained on these 6 fields because the factory was not receiving beets at the time of the survey.

The 'tare bags' were transported to the tare laboratory of American Crystal Sugar Company at East Grand Forks, Minnesota, for further analysis. At the tare laboratory the roots were washed, weighed, and sawed to obtain pulp for determination of sucrose, nitrate grade, and conductivity grade. Percent crown tissue was calculated using the weight of the crown material removed and the root weight.

Two samples of sugarbeet roots were obtained from grower trucks at six piling stations in the Valley. Samples obtained at Crookston factory, Midway,

Table 5. Effect of time in aerobic and anaerobic storage at two temperatures on bacterial populations in sugarbeets obtained from commercial piles stored for 130 days before sampling.

Days in storage	Temp	Number bacterial colonies X 10^6/ml juice	
		Positive*	Negative
0		0.005**	0.066
		anaerobic	
7	26	18.520†	0.001
14	26	21.701	0.017
21	26	1.205	0.627
28	5	0.008	0.050
		aerobic	
7	26	0.028	0.008
14	26	0.037	0.066
21	26	4.791	0.050
28	5	0.003	0.038

* Positive = bacteria capable of sucrose hydrolysis in vitro.
Negative = bacteria not capable of sucrose hydrolysis in vitro.
**Mean of all roots tested at day 0 (n = 80).
† Mean of 5 roots/replicate with two replicates.

Table 6. Effect of time in aerobic and anaerobic storage at two temperatures on bacterial populations in freshly harvested sugarbeets.

Days in storage	Temp	Number bacterial colonies X 10^6/ml juice	
		Positive*	Negative
0		0.001**	0.012
		anaerobic	
7	26	81.035†	11.312
14	26	7.208	1.931
21	26	1.315	0.829
28	5	0.004	6.984
		aerobic	
7	26	0.009	0.030
14	26	0.008	0.099
21	26	0.004	0.125
28	5	0.004	2.491

* Positive = bacteria capable of sucrose hydrolysis in vitro.
Negative = bacteria not capable of sucrose hydrolysis in vitro.
**Mean of all roots tested at day 0 (n = 80).
† Mean of 5 roots/replicate with two replicates.

Effect of Crown Material on Yield and Quality of Sugarbeet Roots: A Grower Survey

Sugarbeets are normally flailed and scalped before harvesting. The purpose of scalping is to remove a portion of the crown material which is known to be

Hillsboro factory, Drayton factory, and Hamilton consisted of 10 roots selected at random from a loaded truck. The samples from the Moorhead factory were obtained by using the sample bucket on the piler to catch two samples per truck load. One sample from each load was used to determine the weight of the crown material that was delivered to the factory by the grower. Both samples were used to measure sucrose, nitrate grade, and conductivity grade at the tare laboratory.

Average length of row to harvest 10 sugarbeet roots varied from 11.6 to 12.1 ft (Table 7), which would give an average population of 19,721 to 20,434 plants per acre. Sugarbeet roots harvested from the grower-scalped row were lower in sucrose compared to sugarbeets harvested from the row with intact leaves which was used to simulate flailing. The reduced sucrose levels were probably a result of respiration caused by the scalping and, also, the grower-scalped sugarbeet roots had had the leaves removed for an undetermined time period which could have reduced the sucrose level due to elimination of photosynthesis, whereas the flailed sugarbeets were capable of photosynthesis up to harvest.

Table 7. Length of row to harvest 10 beets, sucrose, nitrate, conductivity, percent crown, and yield averaged over all growers.

Sample†	n	Row length ft	Sucrose %	Nitrate	Conduct-ivity	Crown %	Yield Crown T/A	Yield Root T/A	Yield Total T/A
1	74	11.6±.5††	16.4±.1	2.8±.1	4.0±.2				18.8±.4
2	74	11.7±.3	16.6±.1	2.6±.1	3.8±.2	19.4±.4	3.7±.2	15.3±.5	19.0±.6
3	68	11.8±.3	16.1±.2	2.9±.1	4.1±.2				18.0±.6
4	68	12.1±.4	16.4±.2	2.8±.1	3.8±.2	15.5±.6	1.8±.1	15.2±.4	18.0±.5

† 1) Flailed, 2) flailed, crown removed manually; 3) grower-topped; 4) grower-topped, remaining crown removed manually.
††Mean with standard error of the mean.

Removal of the entire crown (sample 2, Table 7) resulted in a 1.2% increase in sucrose, a 7.1% reduction in nitrade grade, a 5% reduction in conductivity grade, and an 18.6% reduction in yield compared to sugarbeet roots with intact crown (sample 1, Table 7). Removal of the crown material remaining on sugarbeet roots after scalping by the grower (sample 4, Table 7) resulted in a 1.9% increase in sucrose, a 3.4% reduction in nitrate, a 7.3% reduction in conductivity, and a 15.5% reduction in yield compared to grower-scalped sugarbeet roots (sample 3, Table 7).

Sugarbeet crown material accounted for 19.4% of the total yield for the flailed roots and 15.5% of the total yield for the grower-scalped roots (Table 7). This would indicate that a considerable amount of the crown material is harvested and delivered to the factory.

An inverse relationship exists between sucrose and nitrate grade (Fig. 6). Flailed and grower-scalped sugarbeet roots exhibited similar trends in sucrose reduction with nitrate grade.

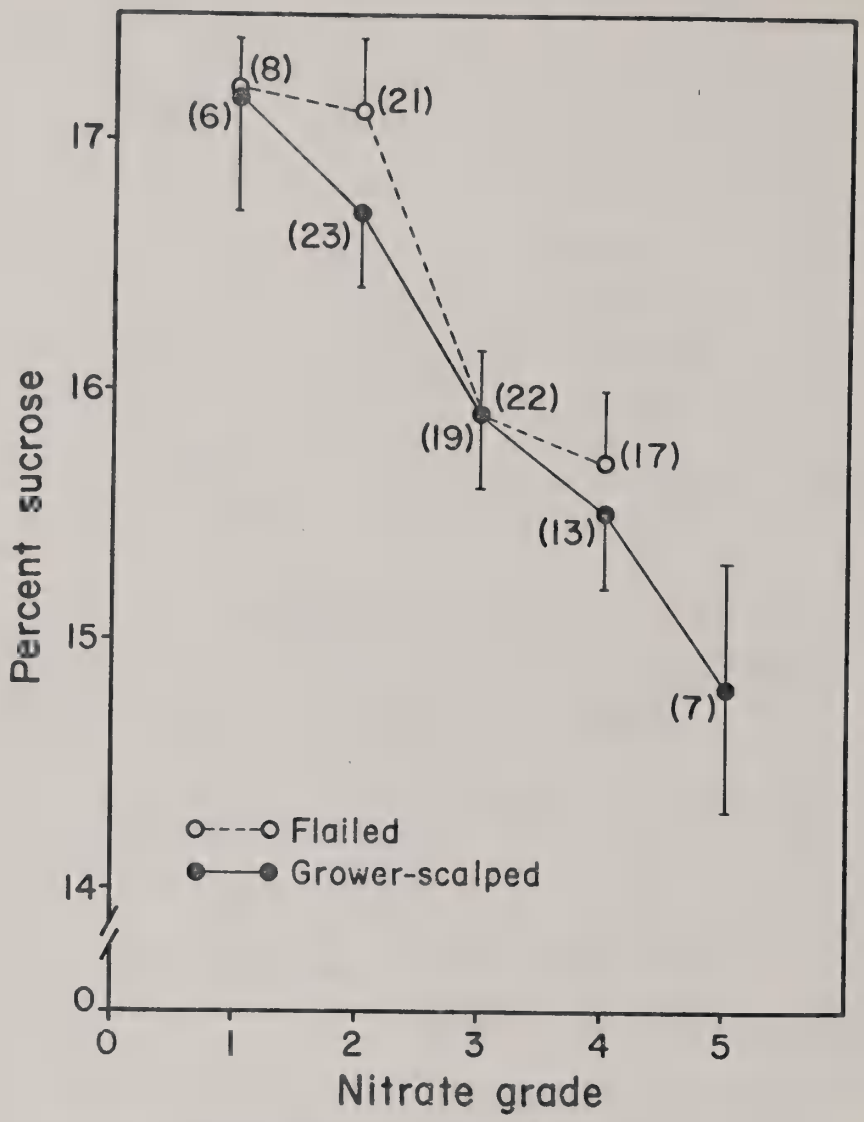

Fig. 6. Relationship between percent sucrose and nitrate grade.

A positive relationship between soil nitrate levels and percent crown tissue has been established. A similar relationship was observed between nitrate grade and percent crown (Fig. 7). This relationship indicates that the amount of crown material produced can be regulated by nitrogen management. Nitrogen management can result in an increase in sucrose content and a reduction in crown material.

Sucrose content showed a decline as percent crown material increased in both flailed and grower-scalped sugarbeet roots (Fig. 8 and 9). A highly significant negative correlation was observed between sucrose and crown material. This relationship can partially be explained by the differential between sucrose level of root vs crown material, since the difference becomes larger as nitrogen increases. Nitrogen causes a reduction in sucrose and an increase in the amount of crown produced.

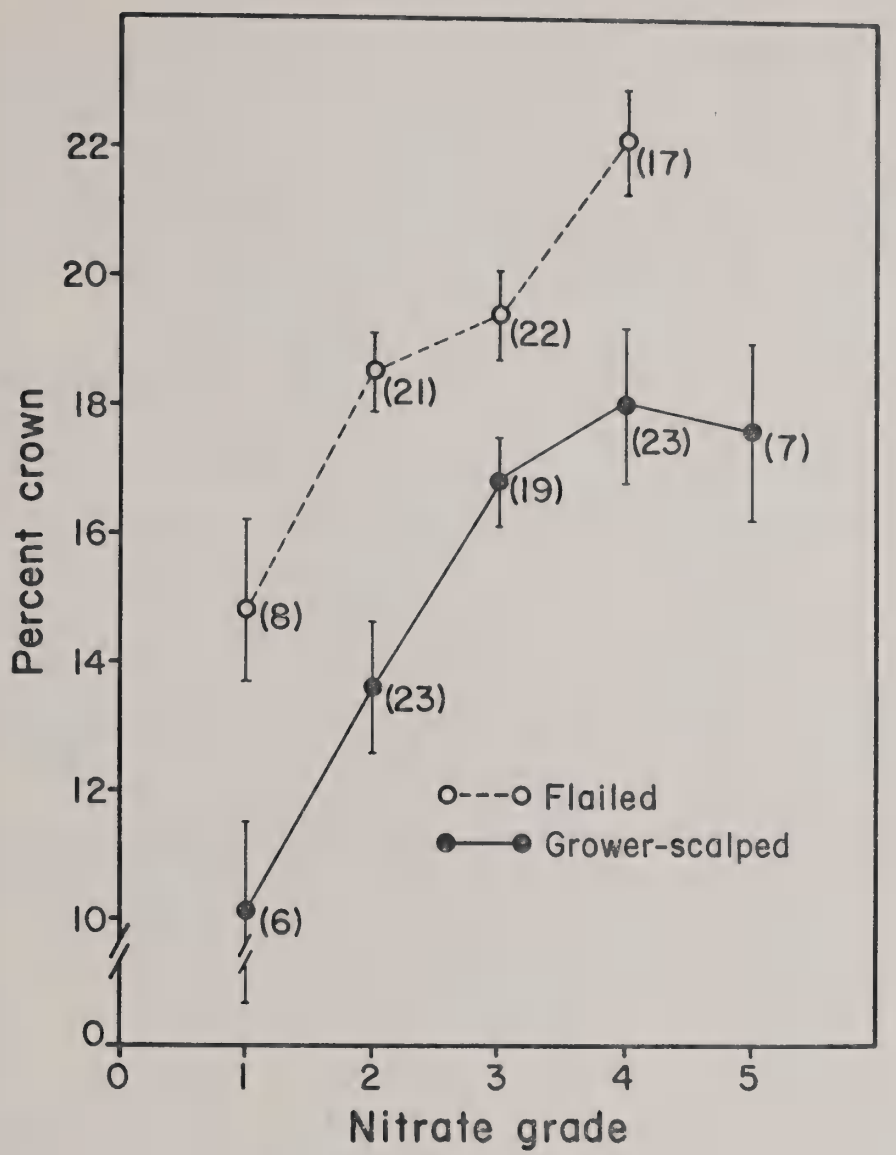

Fig. 7. Relationship between percent crown and nitrate grade.

The data reported above were obtained from manually harvested roots where the tap root and lateral roots remained primarily intact. However, sugarbeet roots harvested mechanically rarely have lateral roots and the main tap root may be broken or cut by the lifter wheels. Therefore, a change in percentage crown material would be expected when comparing manually harvested to mechanically harvested roots.

Crown material accounted for 20.5% of the tonnage delivered to the piler and/or factory station by the growers (Table 8). Removal of all the remaining crown material resulted in a 1.2% increase in sucrose, a 5.3% reduction in nitrate grade, and a 2.2% reduction in conductivity grade (Table 8) averaged over all locations.

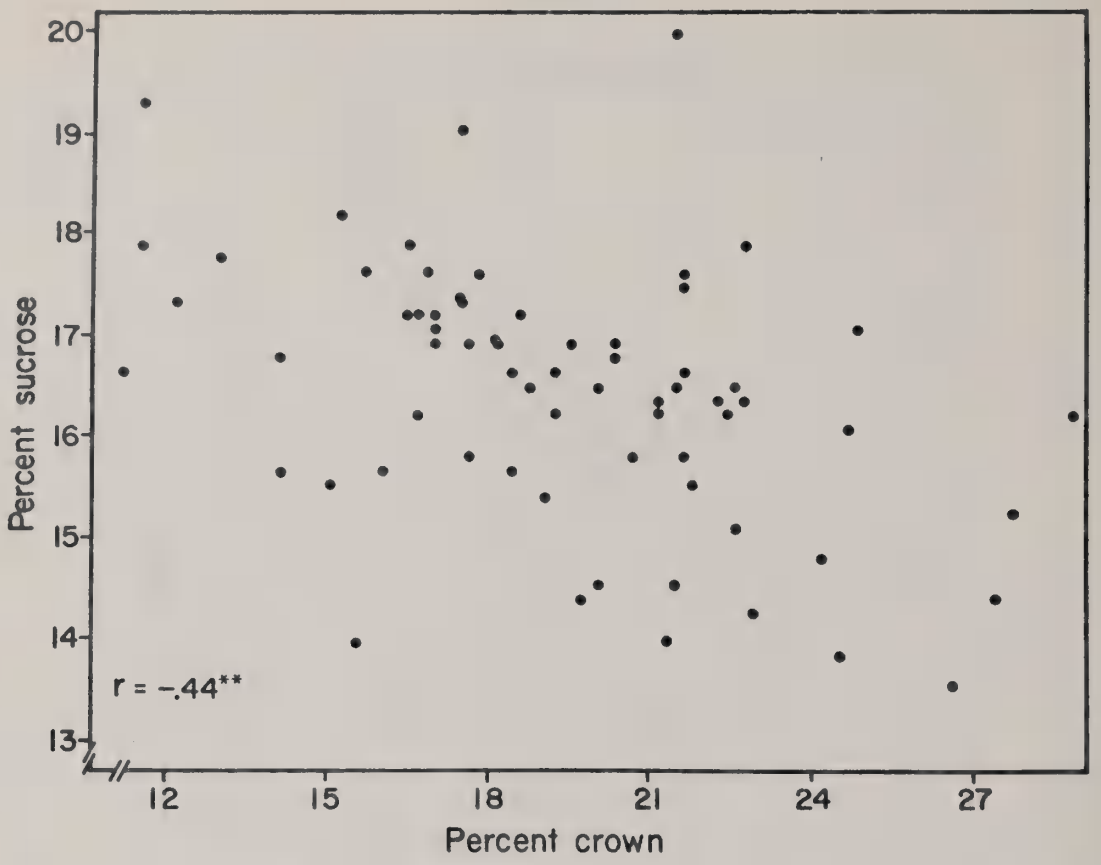

Fig. 8. Relationship between percent sucrose and percent crown (flailed samples).

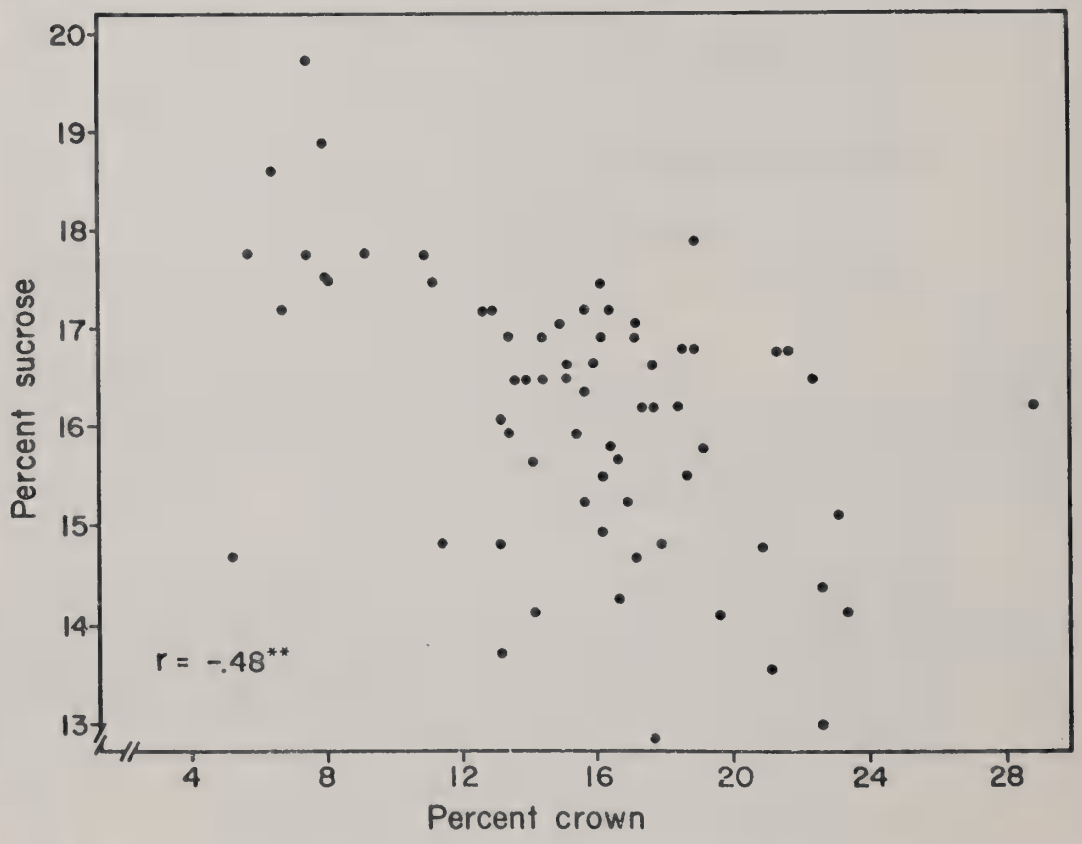

Fig. 9. Relationship between percent sucrose and percent crown (scalped samples).

The data indicate that the factories are processing at least 15.5% of all crown material produced, which accounts for 20.5% of the total tonnage processed. The data indicated that the grower removed 20% of the crown material produced. Assuming a 13.5 T/A yield, the grower could expect an additional 0.7 T/A from crown material if he flailed rather than scalped the beets. This would increase the amount of crown material being processed by the factory to 24.6% of the total tonnage processed. The total tonnage processed by the factory from 50,000 acres would be increased from 675,000 to 710,000 tons. The additional tonnage would increase the slicing campaign 7 days for a 5,000 ton per day factory.

Table 8. Sucrose, nitrate, conductivity and percent crown of sugarbeet roots selected from grower-trucks at selected piles and/or factory locations in the Red River Valley.

Location	n	Sucrose 1†	Sucrose 2	Nitrate 1	Nitrate 2	Conductivity 1	Conductivity 2	Percent crown
Crookston	5	16.4	16.4	3.4	3.4	3.4	3.4	15.3
Midway	11	16.7	16.9	3.7	3.5	5.0	4.7	17.8
Hillsboro	10	17.1	17.6	3.2	2.8	4.5	4.6	15.7
Hamilton	7	17.5	17.6	2.6	2.7	2.7	2.6	13.8
Drayton	10	16.4	16.8	3.4	3.2	4.3	3.9	17.8
Moorhead	46	15.2	15.4	4.2	4.1	5.0	5.0	24.4
Mean	89	16.0±.1	16.2±.2	3.8±.1	3.6±.1	4.6±.1	4.5±.1	20.5±.6

† 1 = Analysis of sugarbeet roots as delivered by grower
2 = Analysis of sugarbeet roots with crown material removed to lowest leaf scar.

SUGARBEET RESEARCH

1975 Report

Section E

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American Crystal Sugar Company
Holly Sugar Corporation
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Michigan Sugar Company
Monitor Sugar Division
Northern Ohio Sugar Company
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The research was supported in part by funds provided through the Beet Sugar Development Foundation (Projects 20 and 26).

CONTENTS

Evaluation of Sugarbeet Hybrids

G. J. Hogaboam

The evaluation program in 1975 was cooperative with the Farmers & Manufacturers Beet Sugar Association and its member companies. Hybrid seed was offered to sugar companies East of the Rocky Mountains for evaluation and report. The American Crystal Sugar Company cooperated in this program. They provided results of 36 tests conducted in 1975 and 17 tests conducted in 1974.

The sugar and purity analyses were conducted by M. G. Frakes, Director of Research, Michigan Sugar Company. The percent sucrose, percent clear juice purity, and recoverable white sugar per ton were determined according to "A rapid and practical method of determining extractable white sugar, as may be applied to the evaluation of agronomic practices and grower deliveries in the sugarbeet industry", by S. T. Dexter, M. G. Frakes, and F. W. Snyder, as published in the Journal of the American Society of Sugar Beet Technologists, Vol. 14, No. 5.

Most of the varieties in the USDA Area Evaluation Test were included to evaluate combinations of SP*xx*550-*x* X SP6822-0 in search of specific combining ability for yield. None were significantly better than US H20. Some exceeded US H20 in recoverable white sugar per ton by a significant amount. Entries 21, 22, and 23 in both tests were too low in stand for the other data to be considered credible.

New hybrids were screened in the Agronomic Nursery Tests. The better ones will be given more extensive testing in 1976.

1975 USDA Area Evaluation Test, Schroeder Farm, Ottawa, Ohio

Entry No.	Seed Source Code	Varieties	PERFORMANCE AS % OF GENERAL MEAN (GM) OF TEST					
			RWS/A	Tons/A	RWS/T	% Sucrose	% CJP	Beets /100'
1	014482	SP71517-01 X SP71550-0 X SP6822-0	98.04	98.08	99.84	99.89	99.99	100.34
2	014483	SP71601-02 X SP71550-0 X SP6822-0	96.25	98.77	97.42	98.03	99.73	99.99
3	014484	SP71614-01 X SP71550-0 X SP6822-0	90.28	90.25	99.91	100.09	99.91	92.78
4	014485	SP70618-01 X SP71550-0 X SP6822-0	100.21	98.96	101.79	101.80	99.95	103.43
5	014486	SP71621-01 X SP71550-0 X SP6822-0	95.37	92.33	103.05	102.18	100.41	96.56
6	014487	SP70640-01 X SP71550-0 X SP6822-0	94.90	94.41	100.12	99.74	100.21	104.46
7	014488	SP70641-01 X SP71550-0 X SP6822-0	96.65	94.90	101.86	100.91	100.49	104.81
8	014489	SP71720-01 X SP71550-0 X SP6822-0	102.54	100.16	102.04	102.00	99.96	91.75
9	014490	SP72730-01 X SP71550-0 X SP6822-0	97.02	94.31	102.69	103.30	99.60	102.74
10	010051	UI11866 X 12166 X SP6322-0 (US H20)	105.07	108.28	97.05	97.36	99.90	114.43
11	014491	SP71735-01 X SP71550-0 X SP6822-0	101.60	103.13	97.95	98.86	99.51	104.81
12	014492	SP70745-02 X SP71550-0 X SP6822-0	107.35	99.66	107.56	105.57	100.89	102.06
13	014493	SP70756-01 X SP71550-0 X SP6822-0	99.31	99.36	99.99	100.21	99.86	99.65
14	014495	SP73614-01 X SP6822-0	103.45	99.66	103.62	102.67	100.42	98.62
15	014496	SP69523-01 X SP6822-0	104.31	106.59	97.62	97.76	99.97	105.84
16	014497	SP69588-01 X SP6822-0	96.90	97.18	99.44	99.68	99.88	97.93
17	014498	SP70682-01 X SP6822-0	110.92	118.18	93.57	95.10	99.28	112.02
18	014499	SP73747-01 X SP6822-0	109.30	110.06	99.55	99.05	100.30	124.39
19	047401	SP70550-01 X SP74564-0 X SP7222-0	101.81	101.05	100.15	100.37	99.87	103.43
20	012106	SP71550-01 X SP6822-0(US H21)	96.82	90.15	107.20	105.19	100.91	107.90
21	047402	SP70550-01 X SP74566-0 X SP7222-0	107.59	108.58	99.19	99.47	99.85	80.06
22	047403	SP70550-01 X SP74571-0 X SP7222-0	95.02	95.50	99.41	99.72	99.83	79.72
23	047404	SP70550-01 X SP74574-0 X SP7222-0	80.81	84.60	95.40	96.38	99.57	64.94
24	019045	UI100363 X 12163 X SP6822-0	108.36	115.71	93.41	94.50	99.56	107.21
		LSD 5% as % GM	NS	14.5043	5.1617	3.7537	0.8208	12.9632
		GM	5925.43	24.43	42.71	14.82	93.15	80.83
		CV %	13.81	12.68	4.51	3.28	0.72	11.33

1975 USDA Area Evaluation Test, Smith Farm, Alma, Michigan

Entry No.	Seed Source Code	Varieties	PERFORMANCE AS % OF GENERAL MEAN (GM) OF TEST RWS/A	Tons/A	RWS/T	% Sucrose	% CJP	Beets /100'
1	014482	SP71517-01 X SP71550-0 X SP6822-0	91.83	92.27	99.54	99.48	100.04	97.43
2	014483	SP71601-02 X SP71550-0 X SP6822-0	95.13	97.36	97.19	98.45	99.35	98.06
3	014484	SP71614-01 X SP71550-0 X SP6822-0	94.66	93.08	101.28	100.94	100.15	98.39
4	014485	SP70618-01 X SP71550-0 X SP6822-0	103.81	103.96	99.75	100.09	99.81	110.92
5	014486	SP71621-01 X SP71550-0 X SP6822-0	91.19	88.69	102.64	101.98	100.32	93.56
6	014487	SP70640-01 X SP71550-0 X SP6822-0	98.82	98.64	100.39	100.33	100.05	111.25
7	014488	SP70641-01 X SP71550-0 X SP6822-0	94.14	92.74	101.62	101.19	100.21	102.57
8	014489	SP71720-01 X SP71550-0 X SP6822-0	103.38	101.64	102.01	101.06	100.49	103.85
9	014490	SP72730-01 X SP71550-0 X SP6822-0	101.04	97.94	103.09	102.40	100.33	95.49
10	010051	UI11866 X 12166 X SP6322-0(US H20)	110.90	108.00	102.56	101.25	100.68	127.64
11	014491	SP71735-01 X SP71550-0 X SP6822-0	102.53	105.46	97.28	98.36	99.43	99.67
12	014492	SP70745-02 X SP71550-0 X SP6822-0	102.70	99.79	103.19	102.39	100.36	109.64
13	014493	SP70756-01 X SP71550-0 X SP6822-0	107.89	109.16	99.03	99.54	99.73	91.64
14	014495	SP73614-01 X SP6822-0	95.76	93.20	102.94	102.52	100.17	99.02
15	014496	SP69523-01 X SP6822-0	102.71	102.56	100.02	99.97	100.05	105.78
16	014497	SP69588-01 X SP6822-0	103.01	103.84	99.31	99.48	99.92	93.56
17	014498	SP70682-01 X SP6822-0	108.95	111.12	98.22	98.02	100.16	123.15
18	014499	SP73747-01 X SP6822-0	101.88	103.96	98.11	98.13	100.04	100.96
19	047401	SP70550-01 X SP74564-0 X SP7222-0	106.95	107.77	98.97	99.27	99.85	112.21
20	012106	SP71550-01 X SP6822-0(US H21)	94.23	92.50	101.93	101.17	100.39	104.49
21	047402	SP70550-01 X SP74566-0 X SP7222-0	101.83	102.80	98.81	99.34	99.73	82.31
22	047403	SP70550-01 X SP74571-0 X SP7222-0	94.89	94.24	100.47	100.36	100.05	75.24
23	047404	SP70550-01 X SP74574-0 X SP7222-0	86.72	92.04	93.52	95.87	98.78	65.91
24	019045	UI100363 X 12163 X SP6822-0	104.90	107.08	97.96	98.39	99.81	97.09
		LSD 5% as % GM	NS	13.16	3.90	2.50	0.82	16.51
		GM	6145.16	22.42	273.62	16.45	93.68	86.39
		CV %	12.31	11.50	3.41	2.18	0.71	14.43

Evaluation of Disease Resistance in Breeding Lines and Varieties for the Great Lakes Area in 1975

G. J. Hogaboam and C. L. Schneider

1. Aphanomyces black root - Four greenhouse screening tests of resistance to the beet water mold, Aphanomyces cochlioides were conducted with 169 entries. There were 6 replicated 4-in. pots of each entry, each with approximately 15 seedlings, infested with vermiculite-oospore inoculum at seeding. Oospore density ranged from 1.0-3.0x10^4 spores/pot, according to the test. Commercial check variety, US H20 was included in each test as a standard for comparison. Highly susceptible variety, Synthetic Check, was also included in three of the tests. Plants were rated numerically, from 0 to 5, according to disease severity, 30 days after emergence.

There were significant differences in disease severity ratings between entries in each test (Table 1). A few lines were rated significantly lower (more resistant) than variety US H20. Seedlings with relatively low degree of disease damage were selected as possible sources of black root resistance.

2. Cercospora leaf spot - In 11 experiments, there were a total of 296 entries listed in the leaf spot nursery at East Lansing. For each entry there were 3 replicated one-row plots, each 5.03 m long. In each experiment there were check varieties as standards of comparison, including US H20 (in all experiments), US H21 (in all except Expt. 6) and SP6926-01 x12166xEL40 (in Expts. 1-5). On 25 June, plots were infested with dried leaf inoculum of Cercospora beticola. Inoculum was applied along plant rows at the rate of 6.6 ml/m with a tractor-mounted modified granule applicator. By late July, disease incidence was 100%. Plots were graded according to leaf spot severity on 20 and 28 Aug.

There were significant differences among entries in each experiment. (Table 2). In experiments 1-5, a preponderant number of entries (65.2%) were rated as significantly lower (more resistant) than the average of three check varieties.

3. Rhizoctonia crown rot - In the Rhizoctonia nursery at East Lansing were 5 experiments, each comprising 33 entries, plus 3 check varieties: US H20, US H21, and SP6926-01x12166xEL40. Line FC701/5, representing close to the highest level yet attained in the Rhizoctonia resistance breeding program, was also included for observation in each test. There were 3 replicated one-row plots, each 5.03 m long, of each entry. On 11 July, dried barley inoculum of a crown and root rotting isolate of Rhizoctonia solani (Rs-12-7) was applied along the plant rows and into the crowns at the rate of 13.7 ml/m with a tractor-mounted modified granule applicator. On 24 September pre-harvest disease ratings were assigned each plot. Each plant was graded from 1 to 4 according to intensity of crown rot symptoms. A percent crown rot rating for each plot was computed by summating individual plant ratings and dividing by 4 (highest rating) x pre-inoculation stand.

There were differences in percent crown rot infection among entries (Table 3). Among all entries tested, 26.1 percent had crown rot significantly lower than that of the three check varieties averaged. Some of the entries with improved resistance are derived from local breeding lines whereas others are derived from Fort Collins lines. From entries with significantly lower ratings, roots were selected as possible sources of the resistance in the breeding program.

4. Powdery mildew - From late September through October, powdery mildew (Erysiphe polygoni type) was observed in commercial stands throughout the Michigan beet growing areas. In agronomic test plots at Alma, where disease incidence was close to 100%, differences in symptom intensity among various test entries were readily apparent. We therefore, on 22 October, rated all plots in the three experiments, according to numerical index from 0 - 9, to indicate relative degree of mildew development.

In each of the 3 experiments, there were significant differences in powdery mildew intensity ratings among entries. Approximately 41% of the entries in all the tests had ratings lower than average of US H20 and US H21, included in each test. These differences indicate the possibility of breeding for powdery mildew resistance should the disease ever become important in the eastern area.

Table 1. Summarized results of 1975 greenhouse screening tests of sugarbeet lines for resistance to Aphanomyces blackroot disease.

Experiment No. and types of entries	No. ent.	Disease rating 1/ Mean & range	US H20	Syn. ck.	LSD (.05)	CV (%)	No. entries in each check variety comparison class 2/ Higher	Same	Lower
1) USDA (East Lansing) breeding lines	140	3.1(2.3-3.7)	3.0	3.8	0.5	15.3	8	128	4
2) F&M area commercial variety test-1974	8	2.2(1.8-2.6)	2.1	2.5	0.5	18.8	0	8	0
3) USDA EL42 component lines	15	2.9(2.4-3.6)	2.1	-	0.6	18.7	12	3	0
4) F&M area commercial variety test-1975	5	3.3(2.8-3.7)	3.0	4.4	0.4	12.4	2	3	0

1/ Disease ratings indicated are based on a severity index from 0 (no symptoms) to 5 (plants dead). Results based on 6 replicates.

2/ Disease ratings of entries compared to that of check variety US H20 at 5% level of significance. Classes indicate higher, same, or lower disease severity than check variety.

Table 2. Summarized results of field test of sugarbeet breeding lines and varieties for resistance to Cercospora leaf spot at East Lansing, Michigan in 1975.

Experiment No. and types of entries	No. ent.	Disease rating 1/ Mean & range	US H20	US H21	LSD (.05)	CV (%)	No. entries in each check variety comparison class 2/ Higher	Same	Lower
1) Beltsville monogerm lines	33	2.0(1.0-2.7)	3.0	2.3	0.8	24.6	0	9	24
2) Beltsville multigerm lines	32	1.9(1.0-3.0)	3.7	2.0	0.9	27.1	0	9	23
3) East Lansing multigerm lines	33	2.3(1.3-4.0)	3.0	2.3	0.9	22.9	1	17	15
4) East Lansing monogerm lines	33	2.6(2.0-3.7)	3.7	3.0	0.7	16.6	0	15	18
5) East Lansing monogerm lines	33	2.4(1.7-3.0)	3.7	2.7	0.7	16.3	0	6	27
6) East Lansing hybrids	33	2.9(2.3-3.3)	3.3	-	0.8	16.5	0	25	8
8) East Lansing misc. hybrids & odd lots	16	3.4(2.3-4.7)	3.3	2.3	0.7	12.7	6	10	0
9) USDA area evaluation test	22	3.0(2.3-3.7)	3.3	2.7	0.9	17.9	0	22	0
10) F&M commercial variety test	4	3.6(3.3-4.3)	4.0	2.3	0.8	12.0	2	2	0
11) F&M	14	4.0(3.7-4.7)	4.0	2.7	N.S.	15.2	0	14	0
12) F&M screening test	33	3.3(2.3-5.0)	3.5	2.3	1.0	19.3	3	29	1

1/ Disease ratings based on an index from 0 (no symptoms) to 9 (complete defoliation) and expressed as means of 3 plots.

2/ Disease ratings of entries compared to that of check variety mean in each experiment (US H20, US H21, and SP6926-01x12166xEL40 in experiments 1, 2, 3, 4, 5; US H21 in experiment 6, and US H20 and US H21 in all other experiments). Classes indicate disease ratings significantly higher (more susceptible), the same, or lower than check variety mean.

Table 3. Summarized results of field test of sugarbeet breeding lines for resistance to crown rot in Rhizoctonia nursery at East Lansing, Michigan in 1975.

Experiment No. and types of entries	No. ent.	Disease rating (Pct. crown rot) 1/ Mean & range	Av. 3 ck.vars.	FC701/5	LSD (.05)	CV (%)	No. entries in each check variety comparison class 2/ Higher	Same	Lower
1) Beltsville monogerm lines	33	76.5(43.8-95.3)	80.3	49.9	NS	22.0	0	33	0
2) Beltsville multigerm lines	33	62.3(43.6-81.3)	68.4	56.2	25.0	24.4	0	27	6
3) East Lansing multigerm lines	33	56.5(40.9-84.7)	73.6	32.4	18.6	19.7	0	17	16
4) East Lansing monogerm lines	33	55.9(34.7-81.5)	72.3	36.3	18.7	20.0	0	19	14
5) East Lansing monogerm lines	33	66.0(49.5-94.5)	73.7	32.5	17.8	16.4	0	26	7

1/ Results based on means of 3 one-row plots, each 5.03 m long.

2/ Disease ratings of entries compared to mean of check varieties US H20, US H21, and SP6926-01x12166x EL40 in each experiment. Classes indicate disease ratings significantly higher, the same, or lower than check variety mean.

Table 4. Powdery mildew ratings of sugarbeet varieties in field plots at Alma, Michigan on 22 Oct. 1975, summarized.

Experiment No. and types of entries	No. ent.	Powdery mildew intensity rating 1/ Mean & range	US H20	US H21	LSD (.05)	CV (%)	No. entries in each check variety comparison class 2/ Higher	Same	Lower
1) USDA area evaluation test	22	3.1(2.4-4.5)	4.3	2.8	0.6	16.5	1	10	11
2) F&M variety screening test	33	3.3(2.3-4.3)	4.2	3.3	0.7	14.4	0	22	11
3) F&M commercial variety test	4	2.6(1.5-3.7)	3.3	2.2	0.7	21.9	0	2	2

1/ Ratings based on a severity index from 1 (very mild) to 9 (severe), Results are based on 6 plots/entry.

2/ Disease ratings of entries compared to mean of check varieties US H20 and US H21 in each test. Classes indicate disease ratings significantly higher, the same or lower than check variety mean.

Sugarbeet Disease Investigations in 1975

C. L. Schneider

1. Effect of incubation period on in vitro production of Aphanomyces cochlioides oospores. Methods of increasing efficiency in producing oospores for inoculum in greenhouse screening tests of seedling blackroot disease resistance were invested. Numbers of oospores/ml produced in flasks of 0.5% oatmeal homogenate broth increased as the incubation periods up to 40 days. Spore production in medium adjusted to pH 6.5 with HCl exceeded spore production in non-adjusted medium. At incubation periods beyond 50 days, spore production tended to decrease in adjusted medium.

2. Effect of components in potting mix on experimental blackroot infection. The components of potting mixtures used in greenhouse inoculation of sugarbeet seedlings with A. cochlioides affected subsequent disease development. Disease severity of seedlings in pots of a 2:1:1 (V:V:V) mixture of peat: fine vermiculite: arcillite inoculated with oospores of A. cochlioides was significantly lower than that of seedlings in pots of 1:2:2 and 1:3:1 mixtures. Disease development was also substantially lower in plants grown in two commercial potting mixes containing tree bark compost, which evidently inhibits some soil fungi.

3. Development of a methodology for greenhouse testing of Rhizoctonia resistance. The most promising results thus far have been obtained with inoculum consisting of a mycelial suspension prepared by comminuting mycological broth cultures of Rhizoctonia solani for 30 sec in a blender and diluting to 1/16-1/32 volume of the incubation medium. The inoculum was applied at the rate of 10 ml/plant near the roots when plants were approximately 30 days old. Disease severity evaluations, 5-6 weeks later, showed significant differences between resistant (FC701/5) and susceptible (US H20)types provided a sufficient number of plants (15 or more) were tested.

4. The effect of cropping sequence on Rhizoctonia crown rot incidence. Studies at the Saginaw Valley Beet and Bean Research Farm in rotation plots maintained by the Crop and Soil Sciences Department of Michigan State University were continued. Incidence of crown rot in sugarbeet plots included in four cropping systems, each with 2, 3, and 4-year rotation periods, was determined. Cropping systems were as follows: 1) corn, beets; 2) corn, navy beans, beets; 3) navy beans, beets; 4) oats-alfalfa,navy beans, beets. In 1975, as in the previous two years, crown rot incidence in cropping sequence no. 1 (2.1%) was significantly lower than that of no. 3 (6.2%) Incidence in sequence no. 2 and no. 4 was 3.4% and 4.0% respectively. Average results of 1973-1974-1975 surveys show significant differences between cropping systems in crown rot incidence with sequence no. 1 lowest (0.8%) and no. 3 highest (3.4%). Length of rotation period showed no significant effect on disease incidence, nor were there

any significant interactions between sequences x rotation periods. The general level of crown rot in the plots was significantly higher in 1975 than in 1974.

5. Virulence of Rhizoctonia isolates on resistant line FC701/5. In greenhouse inoculation tests with resistant breeding line FC701/5, cultures recently isolated from infected plants collected in Michigan and Ohio commercial plantings were screened for degree of virulence in inciting crown rot. Among 31 cultures tested, one showed a significantly higher level of virulence than all other cultures, including the culture currently used in testing breeding lines in our Rhizoctonia nursery (Rs-12).

6. Pathogenicity of Rhizoctonia isolates from non-sugarbeet hosts. On sugarbeet seedlings, only isolates from sugarbeet were highly pathogenic (> 75% damping off). An isolate from navy bean was moderately pathogenic on sugarbeet seedlings (56% damping off). Isolates from pine, cucumber, alfalfa, and potato were slightly pathogenic (< 1% damping off). Isolates from vetch, eggplant, rutabaga, carrot, pine, flax and potato were non-pathogenic. The only culture from a non-sugarbeet host that incited crown rot in older sugarbeet plants was an isolate from navy bean.

7. Use of infrared (IR) aerial photography to assess Rhizoctonia damage. In a cooperative study with G. R. Safir, Michigan State University, the use of IR aerial photography to evaluate relative productivity of sugarbeet plots exposed to Rhizoctonia crown rot disease was investigated. Enlarged photographic color prints (1:550) from a 457 m altitude of our 1974 and 1975 Rhizoctonia nursery plots, taken in late August, were used. Individual plots, each comprising one row, 5.03 m long, were numerically rated on the photographs according to a scale based on plot color which ranged from 1 (white) to 9 (deep red). The ratings, in increasing order, indicate the relative amount of top growth evident. The correlation coefficients between photo ratings and surface productivity ratings (100-pct crown rot) of 756 plots in 1974 nursery = .61, and of 540 plots in 1975 nursery = .83. The results indicate that IR aerial photography is an aid in preharvest determinations of relative productivity of plots exposed to Rhizoctonia crown rot.

8. Test of fungicides to control leafspot. Surface protectant and systemic fungicides were evaluated in plots of cultivar US H20 artificially inoculated with Cercospora beticola. On the basis of a disease severity index ranging from 0 (no disease) to 9 (complete defoliation) the mean rating of untreated control plot = 5.0. All chemical treatments resulted in ratings significantly below that of the control. Disease ratings on 24 September for each treatment were as follows: benomyl, 0.6 kg/ha = 1.3; methyl benzimidazole carbamate, 0.6 kg = 1.6; thiophanate methyl, 0.6 kg = 1.9; benomyl, 0.3 kg = 2.0; methyl benzimidazole carbamate (6%) + Maneb (72%), 2.4 kg = 2.4; chlorothalonil, 2.4 l = 2.5; thiabendazole, 0.6 l = 2.5; thiabendazole

(basal application), 0.8 l = 2.5; benomyl (basal), 0.6 kg = 2.6; fentin hydroxide, 0.7 kg + spreader-extender = 2.8; fentin hydroxide, 0.7 kg + drift retardant = 2.8; fentin hydroxide, 0.7 kg = 3.1; captafol, 4.7 l = 3.1; captan, 2.8 kg = 3.3.

9. Powdery mildew investigations. Fungicides were tested for efficacy in powdery mildew control. Spray applications of thiabendazole at rates of 0.2 and 0.3 kg/ha on 23 July and 6 August - more than 30 days prior to general appearance of symptoms - did not provide effective control. Applications of the following materials on 19 August and 8 September provided good control: thiabendazole, 0.3 l/ha; benomyl, 0.3 kg/ha; sulfur, 6.4 kg/ha. Some fungicides, applied in the crowns of plants to control Rhizoctonia crown rot, reduced severity indices, ranging from infected 0 (no symptoms) to 9 (very severe) of plots receiving the various treatments (a.i./ha) were as follows: benomyl, 0.6 kg = 1.3; fentin hydroxide, 0.7 kg = 2.7; chlorothalonil, 2.3 l = 3.3; PCNB, 3.3 kg = 3.7; untreated control = 4.3.

Abstracts of Papers Published in 1975

1. Safir, G. R. and C. L. Schneider. 1974. Increased diffusive resistance to water flow of sugarbeets infected by Aphanomyces cochlioides. Proc. Amer. Phytopath. Soc. 1:129 (Abstract). -

   Diffusive resistance of leaves of a blackroot susceptible variety averaged significantly higher than that of a resistant variety, although differences in root rot severity were not yet apparent. Results indicate leaf diffusive resistance may be useful for in situ pre-harvest estimation of root rot severity.

2. Schneider, C. L. and L. S. Robertson. 1975. Occurrence of diseases on sugarbeet in a crop rotation experiment in Saginaw County, Michigan in 1969-1970-1971. Plant Dis. Reptr. 58:194-197.

   Surveys were made of disease occurrence in sugarbeet plots in seven crop sequences treated with high and low rates of fertilizer. In 1969, blackroot severity was higher after sweet clover than after corn or soybeans. In 1971, crown rot incidence was higher after alfalfa than after corn, soybeans, or navy beans.

3. Schneider, C. L. and G. R. Safir. 1975. Infrared aerial photography estimation of yield potential in sugarbeets exposed to blackroot disease. Plant Dis. Reptr. 59:627-631.

   Infrared aerial photography indicated significant varietal and locational differences in degree of foliage development among sugarbeet plots exposed to Aphanomyces blackroot disease. IR photo estimates of foliage quantity correlated highly with pre-harvest visual estimates of foliage vigor and quality and with root yield measurements.

4. Hogaboam, G. J. 1975. Defeating diseases through variety development. Proc. Eighteenth Regional Meetings American Society of Sugar Beet Technologists, pp 56-60.

   The interaction of various disciplines in the development of varieties used in the East are discussed.

BREEDING SUGARBEETS RESISTANT TO BLACK ROOT AND LEAF SPOT

G. E. Coe

Research work on sugarbeets at the Agricultural Research Center, Beltsville, Md., is directed toward varietal improvement of sugarbeets resistant to Aphanomyces black root and Cercospora leaf spot, important diseases in eastern United States.

A shift in the emphasis of the work at Beltsville has taken place in the last year or so. Previously, heavy selection pressure had been applied to increase the level of resistance to leaf spot and black root. These efforts have been reasonably successful, and present breeding lines are much more resistant than the commercial hybrid, USH20. However, in achieving good resistance to these diseases there has been a decline in root yield, most of which is overcome when the breeding lines are used in hybrid combinations. The new research areas being emphasized are reported below, but the program of black root and leaf spot testing is of necessity being continued in order to maintain good levels of resistance.

Improving Root Yields

Field selection of large roots at Beltsville is not necessarily a selection for inherent high-root yield potential. It is rather a selection of plants with the best combination of resistance to the complex of sugarbeet diseases occurring at Beltsville. Cercospora leaf spot has been the main disease restricting root growth at Beltsville, and selecting for large roots has been a factor in improving leaf spot resistance. On the other hand, as high levels of resistance have been achieved selecting large roots from nursery plots has contributed to maintenance of reasonable root yields. A technique for selecting for inherent large root size independent of environmental effects has long been needed. Recent work by Doney, Snyder, and others have supplied good evidence that this can be done by selecting seedlings in growth chambers. Tests are underway at Beltsville to confirm this and to determine if increased inherent genetic vigor is carried over as increased combining ability when sugarbeets selected in growth chambers are used as parents in producing hybrids.

Selecting for Smooth "Soil-free" Roots

In 1974, a selection was made for smoothness of root and freedom from root hairs in the multigerm pollen-fertile line SP6922-0. These were interplanted in the greenhouse with a monogerm male-sterile line, SP71550-01. Seed from the multigerm plants were planted in the nursery and reselected for the smooth rooted characteristic. The hybrid seed from the monogerm male-sterile (SP71550-01 X SP6922-0 smooth root) were tested in the nursery in comparison with USH21. Hence, the hybrids had

in common the female parent but different male pollinators. At harvest, USH21 had only slightly more soil adhering to the roots than the experimental hybrid, but the latter exceeded USH21 in yield and % sucrose. The harvest data are presented in Table 1.

TABLE 1. 1975 harvest data of "smooth-rooted" hybrid and USH21, Beltsville, Md.

Variety	No. Rts. / Acre	Gross Sugar #/Acre	Rt. Yield T/Acre	Sucrose %	SNSS %	Raw Juice Appt. Purity %
USH21	26,100	4007	14.27	14.07	3.14	81.76
Expt. Hybrid	18,500	4289	14.64	14.67	2.91	83.40

The slightly better yield, sucrose content, and quality of the experimental hybrid may be attributable to the previous selection of SP6922-0 from which the smooth-root selections were made.

The multigerm progenies from seed harvested from the smooth-rooted pollinators were somewhat disappointing in that they were not much smoother and did not come out of the ground with much less soil than the parent line, SP6922-0. There was, however, a slightly greater percentage of root apparently smoother than SP6922-0.

Selections derived from sugarbeet X garden beet crosses show much greater promise of being soil-free than do the smooth-root selections from SP6922-0. This is true of both globe-shaped and spindle-shaped segregates. Some of these segregates harvested in moderately wet difficult conditions came out of the ground with less than 3 gm of adhering soil and can truly be called soil-free. The task now is to develop true breeding lines having this characteristic and to increase the sucrose content. Analyses run on selected spindle-shaped roots of this breeding material are compared in Table 2 with our regular sugarbeet breeding lines harvested at the same time.

TABLE 2. Comparisons of regular sugarbeet breeding lines with lines derived from crosses to garden beets.

Type Material	No. Tested	Av. wt/rt lb	Av. Sucr. %	Range of % Sucrose	Av. SNSS %	Range of % SNSS	Raw Juice Appt. Purity %
Lines derived from garden beet crosses	129 roots	2.0	8.0	4.5-11.4	2.18	1.25-3.38	78.59
Sugarbeet	28 progeny	1.4	12.0	9.9-14.0	2.91	2.10-3.38	80.48

Obviously, the sucrose percent is unacceptable in the "soil-free" roots, and there is no means of predicting how soon backcrossing and selecting will improve the sucrose enough to make them competitive with present sugarbeet varieties. The low content of other solubles (SNSS) is a desirable characteristic resulting in a purity not far below existing varieties. However, the content of other solubles wil undoubtedly increase some in future generations as sucrose percentage increase, but I anticipate purities in soil-free beets will eventually exceed those of existing varieties.

Selecting Sugarbeets for Resistance to Ozone Damage

Ozone damage is not a factor in sugarbeet production in the United States, and it is not likely to become a factor with the emphasis now being given to cleaning up atmospheric pollution. However, an academic study was undertaken in cooperation with Dr. Harry Menser because of his interest in sugarbeets as a ozone test plant. Two cycles of selection were made for resistance to ozone damage and for susceptibility to ozone damage. Experiments indicate that all selections were successful and that resistance is a heritable characteristic. However, an unexpected result was obtained. The first cycle of selection for ozone susceptibility produced a reduced content of nonsucrose solubles in the juice, and the second cycle of selection for ozone resistance resulted in a reduced sucrose content as shown in Table 3.

TABLE 3. Harvest data of ozone selections in the 1974 Beltsville Nursery.

Type Selection	Selection Cycle	Root Wt. Tons/Acre	Av. Wt. Per Rt. lb	Sucrose %	SNSS %
Ozone Resistant	1st	18.26	2.7	14.2	2.75
" "	2nd	21.35	3.0	12.9	2.42
" Susceptible	1st	18.63	3.7	14.0	2.05
" "	2nd	17.52	3.6	14.5	2.07
Check	None	23.05	4.0	14.3	2.84

It is uncertain whether these data reflect a chance result caused by the limited number of selected roots used for seed increases or whether there is in fact an association of ozone susceptibility and low content of nonsucrose solubles. The selection and testing process should be repeated to verify the results.

Testing the Effect of Irregular Stand on % Sucrose and % Other Solubles

Results of an experiment run in 1973 on the effects of irregular stands on sugarbeets were reported in the 1973 Sugarbeet Research Report. Because the results were on the borderline of significance,

the experiment was repeated in 1975 using USH21 and an experimental hybrid, SP(68533-01 X 67550-0) X 72288-0. The latter will be referred to as Hybrid 19. Harvest data of this experiment are presented in Table 4.

TABLE 4. Harvest data of irregular plant spacing test.

Variety	Spacing of plants	Av. Rt. Yield T/A	Av. % Sucrose	Av. % Other Solubles	Av. % Raw Juice Appt. Purity	Av. Wt./ Root in Sugar Sample
USH 21	Next to skips	13.22	12.8	2.41	84.16	1.81
"	No skips	15.92	13.1	2.27	85.23	1.18
Hybrid 19	Next to skips	15.66	14.0	2.54	84.64	2.25
"	No skips	17.92	14.4	2.45	85.46	1.30

The stands in the 1975 experiment were much better than the stands in 1973, but the results were essentially the same. In both hybrids, roots next to skips were larger in size, lower in percent sucrose, and slightly higher in percent of other solubles than roots taken from stands without skips. Under the conditions of this experiment, better yields were obtained from plots with regular stands. The evidence indicates that irregular stands can contribute to poorer quality beets and lower root yield, but are probably not the most important factor in poor quality beets.

New Experimental Breeding Lines

First generation monogerm O-test progenies in the spring of 1975 indicated 58 new potential O-types. This was more than we could increase because of lack of isolation plots; therefore, we sent only the 12 most promising O-types and their male-sterile companion lines (where available) to the 1975 nursery for leaf spot evaluation. Seed increases and crosses to test combining ability will be made in 1976. Foliage vigor and leaf spot resistance evaluations are listed in Table 5.

TABLE 5. Leaf spot ratings of new O-types and MS lines in 1975 Beltsville nursery.

Variety Designation	Foliage Vigor*	Leaf spot Rating**	Variety Designation	Foliage Vigor*	Leaf spot Rating**
76590-0 PF	2.00	3.00	76597-0 PF	2.50	3.00
76590-01 MS	3.00	4.00	76597-01 MS	2.75	2.50
76591-0 PF	2.00	3.00	76598-0 PF	3.00	3.50
76592-0 PF	3.00	4.00	76600-0 PF	2.00	4.00
76592-01 MS	3.00	3.00	76600-01 MS	2.00	4.00
76593-0 PF	2.00	3.00	76602-0 PF	3.50	2.50
76594-0 PF	1.50	5.00	76602-01 MS	4.00	3.00
76595-0 PF	1.50	2.00	76603-0 PF	2.50	2.00
76595-01 MS	2.00	3.00	76603-01 MS	3.00	2.50
76596-0 PF	2.00	3.00	SP6922-0 MM	4.00	3.00
76596-01 MS	3.50	3.00	(Resistant Check)		

*Foliage vigor scale: 1 = small foliage, 5 = very large foliage.

**Leaf spot rating scale: 0 = no spots, 10 = death of all leaves.

Only one of the O-types, SP76594-0, has poor enough leaf spot resistance to be discarded without further seed increase or testing. Experimental hybrids will be produced from the remainder.

Twelve additional new male-sterile lines were tested in the 1975 nursery. They stem from cytoplasm of two monogerm male-sterile Beta maritima plants found in 1955 in an importation labeled PI 211874 from Wembury, South Devon, England. It has subsequently had four backcrosses to sugarbeets and five selections. Twenty-five progenies from male-sterile plants of this source crossed to SP73550-0 O-type in 1974 were indexed in the greenhouse in 1975. Fifteen of these F_1 progenies were 100% male-sterile. The other 10 progeny were almost all semipollen fertile and pollen fertile, with only an occasional male-sterile plant present. This is perhaps indicative of a relatively simple genetic difference among plants of the male-sterile line. This new source of cytoplasmic male sterility may be of value as insurance against cytoplasmic susceptibility to some disease similar to the susceptibility in corn of Texas cytoplasmic to southern blight. In addition, it might have better combining ability than the cytoplasm of present male-steriles. All these test progenies were acceptable in leaf spot resistance as can be seen in Table 6.

TABLE 6. Foliage vigor and leaf spot resistance of male-sterile progenies having B. maritima cytoplasm.

Variety Designation	Foliage Vigor*	Leaf spot Rating**	Variety Designation	Foliage Vigor*	Leaf spot Rating**
74319X1 MS	3.00	3.00	74335X1 MS	2.00	2.50
74320X1 MS	2.00	3.00	74336X1 MS	3.00	2.50
74323X1 MS	2.00	3.50	74339X1 MS	3.00	3.00
74324X1 MS	3.00	2.00	74341X1 MS	2.50	2.00
74325X1 MS	3.00	3.00	74343X1 MS	3.00	3.00
74331X1 MS	3.00	2.50	SP6922-0 Check	4.00	3.00
74331X1 MS	3.00	3.00			

*Foliage vigor scale: 1 = small foliage, 5 = very large foliage.

**Leaf spot reading scale: 0 = no spots, 10 = death of all leaves.

These male-sterile plants will be used for seed increase and for combining ability tests.